

LOWER SNAKE RIVER COMPENSATION PLAN:
Oregon Spring Chinook Salmon Evaluation Studies
2016 Annual Progress Report

Oregon Department of Fish and Wildlife
Northeast-Central Oregon Research and Monitoring



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Photo cover: Spring Chinook Salmon spawning on the Upper Grande Ronde River: Photo by Joseph Feldhaus.

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Preface

This annual progress report provides summary information for Lower Snake River Compensation Plan (LSRCP) spring Chinook Salmon programs operated by the Oregon Department of Fish and Wildlife (ODFW) in the Imnaha and Grande Ronde river basins during 2016. Also included in this report are summaries of data collected at Chinook Salmon broodstock collection facilities operated by our co-managers, the Nez Perce Tribe (Lostine River) and the Confederated Tribes of the Umatilla Indian Reservation (Catherine Creek and Upper Grande Ronde River), and funded by the Bonneville Power Administration. These ongoing monitoring and evaluation programs provide technical, logistical, and biological information to managers charged with maintaining viable natural Chinook Salmon populations, and managing hatchery programs and recreational and tribal fisheries in northeast Oregon.

The data in this report serve as the basis for assessing the success of meeting our management objectives and were derived from hatchery inventories, standard databases (e.g., PSMFC, coded-wire tag), through standard sampling techniques, or provided by other agencies. As such, specific protocols are usually not described. When possible, data obtained from different sources were cross-referenced and verified. In cases where expansions of data or unique methodologies were used, we describe protocols in more detail. Additional descriptions of protocols can be found in the 2016 work statement (Ruzycki et al. 2016).

We used coded-wire tag (CWT) data collected from 2014-2016 returns to evaluate smolt-to-adult survival rates, harvest, straying, escapement, and specific information on experimental results. In addition, much of the data that we discuss in this report will be used in separate and specific evaluations of ongoing supplementation and research programs for Chinook Salmon in the Imnaha and Grande Ronde river basins. We began salmon culture evaluations in 1983 and have improved many practices. Progress for work completed in previous years is presented in annual progress reports (Carmichael and Wagner 1983; Carmichael and Messmer 1985; Carmichael et al. 1986a; 1987; 1988; 1999; 2004; Messmer et al. 1989; 1990; 1991; 1992; 1993; Hoffnagle et al. 2005; Monzyk et al. 2006a; b; c; d; e; 2007; 2008a; b; Feldhaus et al. 2010; 2011; 2012a;b; 2014a;b; 2016; 2017a,b) and United States v Oregon production report (Carmichael et al. 1986b).

In this report, data are organized into salmon culture monitoring for juvenile and mature salmon (ages 3-5), CWT recoveries, compensation goals, hatchery and natural escapement monitoring. During the period covered in this report, juveniles from brood year (BY) 2015 were hatched, ponded and tagged, Chinook Salmon smolts from BY 2014 were released, Chinook Salmon from BYs 2011-2013 returned to spawn and some of those salmon were used to create BY 2016.

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EXECUTIVE SUMMARY

For brood year (BY) 2014 smolts released in 2016, we determined that Lookingglass Fish Hatchery reared 1,483,729 smolts. For the Imnaha River Conventional Hatchery Program (CHP), the BY 2014 green egg-to-smolt survival rate was 84.5%, 516,802 smolts were released, and 98.1% of these smolts were visually marked with an adipose fin clip (Ad clip) or internally tagged with a coded-wire tag (CWT). The Ad clip and CWT tag facilitate identification of returning adults as hatchery origin. This was the first release of Imnaha River CHP smolts where managers targeted the mitigation goal of 490,000 smolts. The green egg-to-smolt survival rate of BY 2014 Catherine Creek CHP smolts was 90.0%, we released 165,739 CHP smolts into Catherine Creek, and we estimated that 100% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Upper Grande Ronde River CHP smolts was 90.7%, 240,332 CHP smolts were released into the Upper Grande Ronde River, and 98.0% were identifiable as hatchery origin. The green egg-to-smolt survival rate of Lookingglass Creek CHP smolts was 93.3%, we released 302,589 smolts into Lookingglass Creek, and 98.5% were identifiable as hatchery origin. The green egg-to-smolt survival rate of the Lostine River CHP smolts was 85.4%, 258,267 smolts were released into the Lostine River, and 97.9% were identifiable as hatchery origin.

Mean survival rate of Imnaha River smolts from the release site to Lower Granite Dam was 71%. In the Grande Ronde Basin, the lowest mean smolt survival rate from the release site to Lower Granite Dam was 37% from smolts released into Catherine Creek, and the highest mean survival rate was 64% for smolts released into the Lostine River.

We estimated that 2,211 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River in 2016, 13.8% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 1,732 mature Imnaha River hatchery Chinook Salmon returned to the Lower Snake River Compensation Plan area above Lower Granite Dam in 2016, achieving 54.0% of the hatchery compensation goal (3,210) for the Imnaha River Basin. In addition, we estimated that 756 mature natural origin Chinook Salmon returned to the Imnaha River. An estimated 286 mature hatchery Chinook Salmon were harvested in sport (ODFW) and tribal (CTUIR and NPT) fisheries in the Imnaha River and an estimated 477 mature hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 3.7% of the downstream harvest mitigation goal (12,840)

We estimated that 3,548 mature Grande Ronde Basin hatchery Chinook Salmon returned to the Columbia River in 2016, 12.1% of the total mitigation goal of 29,300 mature hatchery salmon returns. Below Lower Granite Dam, we estimated 683 Grande Ronde Basin hatchery Chinook Salmon were harvested in fisheries, 2.9% of the downstream harvest mitigation goal (23,440). We estimated that 2,859 mature hatchery salmon (324 Catherine Creek, 455 Grande Ronde River, 956 Lookingglass Creek, and 1,124 Lostine River) returned to the compensation area, achieving 48.9% of the compensation goal (5,860) for the Grande Ronde Basin. In 2016, we estimated that 276 hatchery and 266 natural salmon returned to Catherine Creek, 296 hatchery and 98 natural salmon returned to the Upper Grande Ronde River, 925 hatchery and 432 natural salmon returned to Lookingglass Creek, and 1,095 hatchery and 667 natural salmon returned to the Lostine River. In Lookingglass Creek, CTUIR and NPT reported that tribal fishers harvested a total of 59 mature hatchery salmon and ODFW estimated that sport fishers harvested 46 mature hatchery salmon. There were no sport fisheries in Catherine Creek or the Upper Grande Ronde River. No tribal fisheries occurred in Catherine Creek, but tribal fishers

reported the harvest of two hatchery salmon from the Upper Grande Ronde River. In the Lostine River, tribal fishers reported a harvest of 132 mature hatchery salmon in the Lostine River. The ODFW estimated that zero hatchery salmon were harvested by sport anglers in the Wallowa River.

After accounting for the estimated number of unmarked mature hatchery returns, the Oregon Department of Fish and Wildlife trapped 1,191 hatchery and 525 natural Chinook Salmon at the Imnaha River weir and 627 hatchery and 349 natural Chinook Salmon in Lookingglass Creek. The Confederated Tribes of the Umatilla Indian Reservation captured 271 hatchery and 260 natural Chinook Salmon in Catherine Creek and 223 hatchery and 73 natural Chinook Salmon in the Upper Grande Ronde River. The Nez Perce Tribe captured 688 hatchery and 541 natural Chinook Salmon in the Lostine River.

During the 2016 spawn year at Lookingglass Fish Hatchery, we spawned 96 hatchery and 39 natural females from the Imnaha River and collected 578,733 green eggs. From Catherine Creek, we spawned 16 hatchery and 22 natural females and collected 153,333 green eggs. In the Upper Grande Ronde River, we spawned 60 hatchery and 9 natural females, and collected 256,237 green eggs. In Lookingglass Creek, we spawned 56 hatchery females and 21 natural females and collected 250,868 green eggs. In the Lostine River, we spawned 54 hatchery females and 20 natural females and collected 319,692 green eggs. A greater number of eggs were collected from age 4 (82.2%) than age 5 (17.8%) females. The mean egg weight of age 5 females (0.269 g) was greater than that of age 4 females (0.238 g).

In the Imnaha River, the BY 2011 recruits-per-spawner (R:S) ratio was 18.4 for the hatchery program and 0.4 for naturally spawning salmon. In the Grande Ronde Basin, BY 2011 R:S for the CHP component was 6.8 in Catherine Creek, 14.7 in the Upper Grande Ronde River, 10.8 in Lookingglass Creek, and 21.0 in the Lostine River. The natural component R:S for BY 2011 was 0.2 in Catherine Creek, 0.3 in the Upper Grande Ronde River, 0.4 in Lookingglass Creek, and 0.1 in the Lostine River.

In 2016, we observed 481 redds and recovered 319 carcasses during spawning ground surveys in the Imnaha River Basin. Hatchery salmon comprised 49.0% of known origin carcass recoveries. In the Grande Ronde Basin, we observed 1,417 redds and recovered 942 carcasses. We recovered 42 hatchery salmon as in-basin strays (i.e., recovered outside of the stream into which they were released as smolts) and two out-of-basin strays (i.e., released outside the Grande Ronde and Imnaha River basins). The percentage of known hatchery salmon recovered on spawning ground surveys was 35.7% in Catherine Creek, 83.3% in the Upper Grande Ronde River, 66.2% in Lookingglass Creek, 53.0% in the Lostine River, 0.0% in the Minam River, and 16.7% in the Wenaha River.

To estimate pre-spawn mortality (PSM) rates, we examined female carcasses for egg retention. Except for Lookingglass Creek and the Lostine River, fewer than 20 females with an estimable egg retention were recovered. The PSM rates in Lookingglass Creek and the Lostine River were 4.9% and 21.9%, respectively. Based on 19 female carcasses, the PSM rate in the Imnaha River was 15.8%. In the two wilderness streams, the Minam and Wenaha rivers, zero female carcasses were found in the Minam River and all six female carcasses found in the Wenaha River were $\geq 50\%$ spawned.

INTRODUCTION

This annual progress report summarizes spring-summer Chinook Salmon monitoring data collected by ODFW for the Lower Snake River Compensation Plan (LSRCP) in 2016. Also summarized are the associated broodstock monitoring data collected at weirs in the Grande Ronde Basin that are operated by our co-managers, the Nez Perce Tribe (NPT; Lostine River) and Confederated Tribes of the Umatilla Indian Reservation (CTUIR; Catherine Creek and Upper Grande Ronde River). The main objectives of this report are to document and evaluate spring-summer Chinook Salmon culture performance for hatchery programs and achievement of management objectives in the Imnaha and Grande Ronde river basins (CTUIR and NPT have specific program goals for Chinook returns to Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River that are discussed and evaluated in separate reports prepared by each co-management agency). Overall, these data are used to adaptively manage salmon culture practices in order to optimize egg-to-smolt survival rate, smolt quality, smolt-to-adult survival rate, the recruits-per-spawner (R:S) ratio, and to monitor spawning in nature by hatchery-reared salmon.

This report provides information on rearing and release operations for brood year (BY) 2014 of juvenile Chinook Salmon smolts, the collection of eggs for BY 2016, numbers and characteristics (e.g., age composition) of mature Chinook Salmon in the 2016 return year, the 2016 spawning year at Lookingglass Fish Hatchery and in nature, and survival information (e.g., SAR, R:S) for BY 2011. These metrics document the success of these programs in meeting the LSRCP objectives for mature salmon returning to the mitigation area above Lower Granite Dam (LGD) and for harvest below LGD. In order to avoid confusion around whether jacks (age 3) are included with adult metrics, we will use the convention that “adults” include only ages 4 and 5 and “total” or “mature salmon” include all sexually mature salmon ages 3–5.

LSRCP Chinook Salmon Program Objectives

The seven program objectives originally outlined by Carmichael and Wagner (1983) were updated following the 1990 and 1998 symposium reviews (Carmichael et al. 1990, Carmichael et al. 1998). At the request of LSRCP (S. Yundt, personal communication, 2014), definitions for Oregon compensation goals were clarified in Feldhaus et al. (2014a), based on Corps of Engineers (1975) and Herrig (1990). Our compensation goals are now stated as follows:

1. Establish adequate broodstock to meet annual production goals.
2. Establish a consistent total return of Chinook Salmon that meets the LSRCP mitigation goal of 3,210 mature (ages 3–5) hatchery salmon in the Imnaha River Basin and 5,860 mature hatchery salmon in the Grande Ronde Basin with a 4:1 catch to escapement ratio (commercial catch 3:1 and sport catch 1:1) in the Pacific Ocean and the Columbia River System downstream from the Lower Snake River Project Area (Corps of Engineers 1975). The total production goal is 16,050 mature hatchery Chinook Salmon from the Imnaha hatchery program (12,840 mature salmon below LGD and 3,210 mature salmon above LGD) and 29,300 mature hatchery salmon from the Grande Ronde Basin hatchery programs (23,440 mature salmon below LGD and 5,860 mature salmon above LGD; Herrig 1990).

3. Re-establish historic tribal and recreational fisheries.
4. Minimize impacts of hatchery programs on resident stocks of game fish.
5. Prevent extinction of Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River Chinook Salmon populations and ensure a high probability of population persistence well into the future, once causes of basin-wide declines have been addressed
6. Operate the hatchery program so that the genetic and life history characteristics of hatchery salmon mimic those of wild salmon, while achieving mitigation goals.
7. Maintain genetic and life-history characteristics of natural Chinook Salmon populations in the Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River.
8. Maintain the genetic and life-history characteristics of the endemic wild populations of Chinook Salmon in the Minam and Wenaha rivers.
9. Provide a future basis to reverse the decline in abundance of endemic Chinook Salmon populations in the Imnaha and Grande Ronde river basins.

Research Monitoring and Evaluation Objectives

1. Document Chinook Salmon rearing and release activities at all LSRCP facilities in northeast Oregon.
2. Determine optimum rearing and release strategies that will produce maximum survival to adulthood for hatchery-produced Chinook Salmon smolts.
3. Document Chinook Salmon returns of mature salmon to broodstock collection facilities in the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River.
4. Estimate annual returns of mature hatchery salmon to the LSRCP compensation area and total hatchery salmon production, and determine success in meeting mitigation goals.
5. Estimate annual commercial, sport and tribal harvest of Imnaha River and Grande Ronde Basin hatchery Chinook Salmon and determine success in meeting mitigation goals.
6. Estimate annual smolt survival to Lower Granite Dam (LGD) for production and experimental groups.
7. Conduct index, extensive, and supplemental Chinook Salmon spawning ground surveys for all populations in northeast Oregon to assess spawn timing and spawning distribution, and estimate natural spawner escapement.
8. Determine the proportion of naturally spawning spring Chinook Salmon that are of hatchery origin in the Imnaha and Grande Ronde basin Chinook Salmon populations.
9. Determine annual escapement and spawner numbers to estimate and compare productivity (recruits-per-spawner) and survival rates for natural- and hatchery-produced Chinook Salmon in the Imnaha and Grande Ronde basins.
10. Compare life history characteristics (age structure, run timing, sex ratio, egg size, and fecundity) of hatchery and natural origin salmon.
11. Coordinate Chinook Salmon broodstock marking programs for Lookingglass Fish Hatchery.
12. Participate in planning activities associated with anadromous salmon production and management in the Imnaha and Grande Ronde river basins and participate in ESA permitting, consultation, and recovery planning.

METHODS, RESULTS, AND DISCUSSION

During 2016, spring Chinook Salmon from BY 2014 produced from the Conventional Hatchery Program (CHP) were released into the Imnaha River, Catherine Creek, the Upper Grande Ronde River, Lookingglass Creek, and the Lostine River. Mature Chinook Salmon from BYs 2011–2013 returned to spawn and some of these returns were collected from each population to use as broodstock to create offspring for the BY 2016 CHP production. All of these salmon were reared at Lookingglass Fish Hatchery. The 2016 return year was also the final return year for adults from the BY 2011 Upper Grande Ronde River Captive Broodstock Program (CBS) smolts. These age 5 Upper Grande Ronde River CBS returns comprised a portion of the mature hatchery salmon returns to the Columbia River Basin in 2016. Coded-wire-tag (CWT) recoveries from mature hatchery salmon were used to assess the success of achieving mitigation goals and management objectives. In addition, much of the data discussed in this report will be used in separate and specific evaluations of ongoing supplementation programs for Chinook Salmon in the Imnaha and Grande Ronde river basins.

Juvenile Rearing and Release (BY 2014)

Egg to Smolt Survival (BY 2014)

Green egg-to-smolt survival rate for BY 2014 Imnaha River Chinook Salmon released in 2016 was 84.5% (94.3% green egg-to-eyed egg; 89.7% eyed egg-to-smolt; Table 1). Green egg-to-smolt survival rate for Catherine Creek CHP salmon was 90.0% (92.6% green egg-to-eyed egg; 97.3% eyed egg-to-smolt). For the Upper Grande Ronde River, the green egg-to-smolt survival rate was 90.7% (94.5% green egg-to-eyed egg; 95.9% eyed egg-to-smolt) for CHP offspring. For Lookingglass Creek CHP salmon, the green egg-to-smolt survival rate was 93.3% (96.4% green egg-to-eyed egg; 96.8% eyed egg-to-smolt). For Lostine River CHP salmon, the green egg-to-smolt survival rate was 85.4% (93.9% green egg-to-eyed egg; 91.2% eyed egg-to-smolt).

In an effort to reduce the incidence of BKD in Chinook Salmon offspring, the ODFW Fish Health recommends that eggs from female Chinook Salmon from the CHP program with enzyme-linked immunosorbent assay (ELISA) optical density values ≥ 0.2 should be culled. For the BY 2014 production, we culled eggs from two Imnaha, one Upper Grande Ronde River, three Lostine River, and one Catherine Creek female.

Production and Tagging (BY 2014)

The target numbers of hatchery smolts to be produced, tagged, and marked with either an adipose fin (Ad) clip or a coded-wire-tag (CWT) differed among stocks. Therefore, the hatchery origin smolts reared at Lookingglass Fish Hatchery are identified by either an Ad clip, a CWT, or an Ad clip and a CWT (Ad CWT). For BY 2014, the Imnaha CHP production goal was revised from an annual production goal of 360,000 smolts to be equal to the LSRCP mitigation goal of 490,000 smolts. The long-term juvenile production goals for the Grande Ronde Basin remained at 150,000 smolts per year for Catherine Creek and 250,000 smolts per year for each of the Lookingglass Creek, Upper Grande Ronde River, and Lostine River populations.

Each year, we evaluate Ad fin clip and CWT and mark application success by checking 500 juvenile Chinook Salmon from each raceway at Lookingglass Fish Hatchery. The BY 2014

smolts were sampled on either 8 October 2015 or from 8–10 February 2016. We sampled smolts during two different time periods because the ponding plan at Lookingglass Fish Hatchery resulted in smolts marked with only an Ad fin clip being mixed with Ad CWT marked smolts. To accurately represent the proportion of smolts marked with an Ad CWT, sampling had to occur before the Ad marked salmon were mixed with the Ad CWT marked salmon. The intention was for raceways with CWTs to receive a unique code, but as a result of ponding logistics to reduce smolt densities, some raceways received multiple CWT codes. We continue to work with the hatchery to modify ponding plans to prevent the mixing of CWT codes.

The release of 516,802 Imnaha River BY 2014 smolts in 2016 exceeded the annual production and mitigation goal of 490,000 smolts (Table 1). Prior to BY 2014, the production goal was 360,000 smolts (e.g., Feldhaus et al 2017 a,b). We reared six raceways of Imnaha River hatchery smolts and estimated that 58.7% were marked with both an Ad fin clip and a CWT, 36.3% were only marked with an Ad fin clip, 3.1% received a CWT but no Ad fin clip, and 1.9% were released unmarked (Table 2). Overall, 98.1% of the Imnaha River smolts were identifiable as hatchery origin.

We released 165,739 smolts from the BY 2014 CHP production into Catherine Creek in 2016, achieving 110% of the juvenile production goal (Table 1). These smolts were raised in two raceways and we estimated that 67.6% were marked with both an Ad fin clip and a CWT, 32.4% were only marked with an Ad fin clip, 0.0% received an CWT but no Ad fin clip, and 0.0% were released unmarked (Table 2). Overall, 100% of the smolts released into Catherine Creek were identifiable as hatchery origin.

The Upper Grande Ronde River BY 2014 production released 240,332 CHP smolts in 2016, 96.1% of the juvenile production goal (Table 1). This stock is typically raised in four raceways and is unique in the Lookingglass Fish Hatchery production because approximately 50% of the smolts are released with an Ad clip and a CWT and 50% are marked with only a CWT. This marking strategy is achieved by targeting 100% of the smolts in two raceways to be marked with both an Ad fin clip and a CWT. The two remaining raceways of smolts are marked with a CWT but the adipose fin not removed. We estimated that 47.4% of the Upper Grande Ronde River smolts were marked with both an Ad fin clip and a CWT, 1.9% were only marked with an Ad fin clip, 48.7% received an CWT but no Ad fin clip, and 2.0% were released unmarked (Table 2). Overall, 98.0% of the smolts released into the Upper Grande Ronde River were identifiable as hatchery origin.

In Lookingglass Creek, we released 302,589 smolts from the Lookingglass Creek CHP, achieving 121.0% of the juvenile production goal (Table 1). These smolts were raised in three raceways. We estimated that 46.3% of these smolts were marked with both an Ad fin clip and a CWT, 52.2% were only marked with an Ad fin clip, 0.0% received an CWT but no Ad fin clip, and 1.5% were released unmarked (Table 2). Overall, 98.5% of the smolts released into Lookingglass Creek were identifiable as hatchery origin.

In the Lostine River, we released 258,267 CHP smolts, 103.3% of the juvenile production goal (Table 1). These smolts were raised in three raceways, and we estimated that 51.4% were marked with both an Ad fin clip and a CWT, 46.5% were only marked with an Ad fin clip, 0.0% received an CWT but no Ad fin clip, and 2.1% were released unmarked (Table 2). Overall, 97.9% of smolts released into the Lostine River were identifiable as hatchery origin.

Smolt survival to Lower Granite Dam (BY 2014)

We monitored smolt migration success based on survival to Lower Granite Dam (LGD) for all stocks. We compiled release-recapture information for PIT-tagged smolts from each raceway to calculate Cormack-Jolly-Seber survival probabilities (rates) to LGD with a single release recapture model using the PIT Pro 4 Program (Westhagen and Skalski 2009). Mean stock survival was calculated as the mean of the raceways for each stock.

Four raceways of Imnaha River BY 2014 smolts were acclimated at the Imnaha River Acclimation Facility and two raceways were released directly into the Imnaha River at the Imnaha River Acclimation Facility (Table 3). Volitional release of the acclimated smolts began on 1 April 2016. On-site personnel reported that the majority of the smolts volitionally left the facility before the end of the scheduled two week release so all of the smolts remaining in the acclimated group were forced out on 7 April 2016. The direct stream smolts were released on 13 April 2016. The mean survival rate to LGD for smolts released directly into the Imnaha River at the acclimation facility was 71% (range 69-72%). The mean survival rate for the acclimated smolts was also 71% (range 64-76%). The overall mean survival rate to LGD for Imnaha River smolts released in 2016 was 71% (Figure 1).

Volitional release of the two Catherine Creek CHP smolts began on 23 March 2016 and smolts were forced out on 14 April 2016 (Table 3). Mean survival rate to LGD for CHP smolts released into Catherine Creek was 37%. For the sixth consecutive year, smolts released into Catherine Creek had the lowest mean survival rate to LGD for smolts released in the Grande Ronde Basin (Figure 1).

The Upper Grande Ronde River acclimation facility is not large enough to acclimate all four raceways of Upper Grande Ronde River CHP smolts reared at Lookingglass Fish Hatchery simultaneously. Therefore, smolts are transported from Lookingglass Fish Hatchery to the acclimation facility at two different time periods. Volitional release of CHP smolts from the first transfer (i.e., early acclimation), which consisted of two raceways of smolts transferred from Lookingglass Fish Hatchery, began on 21 March 2016, with force-out occurring on 5 April 2016 (Table 3). The second acclimation period (i.e., late acclimate) also consisted of two raceways of smolts transferred from Lookingglass Fish Hatchery. Volitional release of the second group began on 8 April 2016, with force-out occurring on 18 April 2016. The mean survival rate to LGD for smolts released from the Upper Grande Ronde River Acclimation facility was 43% for the early release, 45% for the late release, and the overall survival rate was 44% (Figure 1).

Smolts produced from the Lookingglass Creek CHP were volitionally released into Lookingglass Creek directly from their rearing ponds at Lookingglass Fish Hatchery starting on 1 April 2016 with force-out occurring on 11 April 2016 (Table 3). Mean survival rate to LGD for CHP smolts released into Lookingglass Creek was 76%, the highest mean survival rate for smolts released into the Grande Ronde Basin (Figure 1).

The BY 2014 Lostine River CHP smolts were also split between an early and late acclimation period. Volitional release of the first group (raceway 12 and ~50% of raceway 11) began on 21 March 2016, with force-out occurring on 31 March 2016. Volitional release of the second group (raceway 13 and the remainder of raceway 11) started on 12 April 2016 and smolts were forced out on 20 April 2016. The mean survival rate to LGD for CHP smolts from raceway 12 (early release) was 54%, 61% for raceway 13 (late release), and the overall survival was 58% (Figure 1).

2016 Return Year Chinook Salmon Collections

Returning mature (ages 3–5) salmon are captured at weirs for collection of broodstock and management of hatchery salmon spawning in nature. All salmon captured at weirs are classified by origin (based on tags and marks) and have their fork length measured to estimate age. However, there are known sources of error in these data for which we must compensate.

The first limitation to using weir data to characterize the age and sex composition of returning salmon is that sex determination is based entirely on a visual assessment of external characteristics of a live salmon and it is particularly difficult to determine the sex of early arriving salmon because external morphological characteristics (e.g., male kype) are not well developed. Errors in sex determination result in data discrepancies between the numbers of males and females recorded as being collected at the weir and those recorded as spawned at the hatchery (where sex is accurately determined by examining gonads).

Another limitation of weir data is age determination. Since length-at-age distributions overlap, using a fixed length cutoff is arbitrary (e.g., classifies small age 4 salmon as age 3 and large age 3 salmon as age 4) and may bias the estimated age structure of salmon handled at the weir. In this report, we attempt to correct for size overlap by using known age salmon (i.e., using a CWT, PIT tag, or scale to determine age) to create yearly length-at-age categories (see Feldhaus et al. 2017b Appendix A for detailed methods). We could decrease our error by reducing the number of salmon without a known age by releasing more CWT-marked hatchery salmon, collecting scales on all salmon passed above the weirs, or increase the number of snouts collected on CWT-marked salmon that are killed or sent to foodbanks.

Lastly, some hatchery salmon are unidentifiable due to a combination of poor marking and tag loss. Therefore, it is also sometimes necessary to account for these unidentifiable hatchery returns, which are recorded as natural salmon, by adjusting the hatchery:natural ratios for each age class (i.e., brood year). This adjustment is made by first assigning a final age to each salmon based on known ages (CWTs, PIT tags, or scale ages) or an estimated age based on length if tags or scales are unavailable (see Feldhaus et al. 2017b Appendix A for detailed methods). We then use the percentage of hatchery juveniles from each BY that were released unmarked and untagged (i.e., no CWT and no adipose fin clip) to account for unidentifiable hatchery salmon that would be counted as natural salmon. This reduces the number of natural Chinook Salmon in our estimate and increases the number of hatchery Chinook Salmon from an equivalent age to account for lost or missed marks and tags.

Innaha River

The Innaha River weir was operated by ODFW Lookingglass Fish Hatchery personnel from 16 May to 9 September 2016 (Table 4). This was the first complete year of operations for the new bridge weir, which was constructed in the summer and fall of 2015 in the exact same location as weir it replaced. The first Chinook Salmon was captured on 14 June, 2016 and the last new salmon was captured on 8 September, 2016. After adjusting for unclipped returns, we estimated that 1,191 hatchery and 525 natural-origin mature salmon were captured (Table 5). We retained 201 hatchery- and 82 Chinook Salmon for broodstock. There were six hatchery and two natural origin trap mortalities. To limit the number of hatchery salmon on spawning grounds, 215 hatchery salmon were outplanted to Big Sheep Creek, 10 were distributed to Oregon or Nez Perce Tribal food banks, and 177 were killed and their carcasses disposed of either below the weir or in Big Sheep Creek and Lick Creek for the purpose stream enrichment.

After accounting for Chinook Salmon that were recaptured after being placed below the weir, we determined that 166 hatchery salmon trapped at the weir remained below the weir after being placed below the weir to provide additional harvest opportunities. The remaining salmon collected at the weir were released above the weir to spawn naturally (416 hatchery, 441 natural). Of the hatchery salmon captured at the weir, 18.8% were age 3, 72.0% were age 4, and 9.2% were age 5. Natural origin returns captured at the weir were comprised of 6.3% age 3, 73.5% age 4, and 20.2% age 5.

Catherine Creek

The Catherine Creek weir was operated by CTUIR from 1 March to 5 August 2016 (Table 4). The first Chinook Salmon was captured on 19 May 2016 and the last new (i.e., not a recapture) salmon was captured on 1 August 2016. After adjusting for unmarked hatchery returns, we estimated that a total of 271 hatchery-and 260 naturally-produced salmon were captured (Table 5). CTUIR retained 50 hatchery and 46 natural origin salmon for broodstock. There were two trap mortalities: one hatchery and one natural origin salmon. In 2016, no salmon were outplanted from Catherine Creek to other locations (e.g., Indian Creek, Lookingglass Creek). The remaining 196 hatchery and 213 natural mature salmon, were passed above the weir to spawn naturally. Age structure of hatchery salmon captured at the weir was 15.8% age 3, 77.9% age 4, and 6.3% age 5. Natural origin returns were comprised of 3.8% age 3, 85.4% age 4, and 10.8% age 5.

Upper Grande Ronde River

The Upper Grande Ronde River weir was operated by CTUIR from 1 March to 3 June 2016 (Table 4). The weir was pulled on 3 June because water temperatures reached 18°C. The first Chinook was captured on 23 May 2016 and the last new (i.e., not a recapture) salmon was captured on 3 June 2016. After adjusting for unmarked hatchery returns, we estimated that 223 hatchery and 73 naturally-produced salmon were captured (Table 5). From the Upper Grande Ronde River weir, CTUIR retained 122 hatchery and 30 natural salmon for broodstock, zero hatchery salmon were killed at the weir, there were zero trap mortalities, and 101 hatchery and 43 natural mature Chinook Salmon were released above the weir to spawn naturally. Age structure of hatchery salmon captured at the weir was 1.8% age 3 (100% CHP), 88.7% age 4 (100% CHP), and 9.4% age 5 (20% CBS; 80% CHP). The age 5 CBS returns were identifiable because the adipose fin was removed while the CHP returns had an intact adipose fin. Natural origin salmon were comprised of 1.4 % age 3, 91.8% age 4, and 6.8% age 5.

This is the 12th and final year of returns of mature Upper Grande Ronde River hatchery salmon from the CBS program (BYs 1998 – 2005, 2009, 2011) and the 11th for CHP production (BYs 2001 – 2011). The CBS smolts released into Upper Grande Ronde River from BY 2011 (age 5) were all marked with either an adipose fin clip (53.8%) or an adipose fin clip and a CWT (46.2%). The BY 2011 CHP smolts were only marked with a CWT. There were no releases of CBS smolts into the Upper Grande Ronde River from BY 2013 (age 3) or BY 2012 (age 4) returns).

Lookingglass Creek

The Lookingglass Creek weir was operated by Lookingglass Fish Hatchery (ODFW) personnel from 1 March to 15 September 2016 (Table 4). The first Chinook Salmon was captured on 12 May 2016 and the last new (i.e., not a recapture) salmon was captured on 12

September 2016. After adjusting for unmarked hatchery returns, we estimated that 627 hatchery and 349 naturally-produced salmon were captured (Table 5). The trap total includes 46 assumed strays from the Upper Grande Ronde River CHP program based on the absence of an adipose fin clip and the presence of a CWT. Of the assumed Upper Grande Ronde River strays, five jacks and 39 adults were kept for the Grande Ronde River CHP broodstock program, and two jacks were killed.

Totals of 342 hatchery and 297 natural origin Chinook were passed above the weir to spawn naturally; 106 hatchery salmon were killed (foodbank or landfill), there were zero trap mortalities, and 135 hatchery and 52 natural mature salmon were kept for the Lookingglass Creek CHP broodstock program. Hatchery salmon captured at the weir (includes strays) were comprised of 17.6% age 3, 77.8% age 4, and 4.6% age 5. Natural origin returns captured at the weir were comprised of 1.4% age 3, 94.3% age 4, and 4.3% age 5.

Lostine River

The Lostine River weir was operated by the NPT from 15 February to 27 September 2016 (Table 4). There were unique captures of 688 hatchery- and 541 natural mature salmon at the weir, of which 123 hatchery and 49 natural origin mature salmon were retained for broodstock (Table 5). To reduce the number of hatchery salmon on the spawning grounds, 94 hatchery salmon were released at the confluence of the Wallowa and Minam Rivers to provide additional harvest opportunities for anglers. Additionally, 26 hatchery jack salmon were released into the Wallowa River at Wade Gulch (decimal degrees, WGS84: N45.475166 E -117.387606) and 12 jack salmon were released into the Wallowa River at School Flat Road (WGS84: N45.501760 E -117.415034) for natural spawning. One hatchery salmon was kept by the Nez Perce Tribe for ceremonial purposes. All remaining salmon were passed above the weir to spawn naturally (433 hatchery, 491 natural). Age structure of hatchery salmon captured at the weir was 21.9% age 3, 66.6% age 4, and 11.5% age 5. Age structure of the natural origin salmon captured at the weir was 3.3% age 3, 80.0% age 4, and 16.7% age 5.

2016 Brood Year Hatchery Spawning

Imnaha River

We spawned 96 hatchery and 39 natural females with 73 unique hatchery and 40 unique natural male parents (Table 6). Six jacks were pooled and used as one male and some adult males were spawned multiple times. Counting six jacks as one male is unique to Imnaha River production. Ten hatchery origin and eight natural origin males were live-spawned at Lookingglass Fish Hatchery and returned to the Imnaha River on 9 September 2016. We collected 578,733 green eggs which were incubated at Lookingglass Fish Hatchery where mortality rate to shocking was 3.5%, resulting in 558,531 eyed eggs.

Catherine Creek

We spawned 16 hatchery and 22 natural females with 21 unique hatchery and 15 unique natural male parents (Table 6). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 153,333 green eggs and mortality rate to shocking was 13.6%, resulting in 132,411 eyed eggs.

Upper Grande Ronde River

We spawned 60 hatchery and 9 natural females with 56 unique hatchery and 15 unique natural male parents (Table 6). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 256,237 green eggs and mortality rate to shocking was 7.9%, resulting in 235,878 eyed eggs. Of the 44 hatchery salmon that were captured at the Lookingglass Creek fish trap and placed into the Upper Grande Ronde broodstock ponds (i.e., in-basin strays), 19 were used for spawning (16 females and 3 males). The remainder of the in-basin strays were either killed prior to spawning or died in the hatchery holding ponds.

Lookingglass Creek

We spawned 56 hatchery and 21 natural females with 41 unique hatchery and 23 unique natural origin male parents (Table 6). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 272,810 green eggs and mortality rate to shocking was 8.0%, resulting in 250,865 eyed eggs.

Lostine River

We spawned 54 hatchery and 20 natural females with 44 unique hatchery and 19 unique natural male parents (Table 6). Jacks were used the same as adult males and some adult males were spawned more than once. We collected 319,692 green eggs and mortality rate to shocking was 13.3%, resulting in 277,197 eyed eggs.

Egg Weight

For all stocks, a greater number of females and eggs were collected from age 4 than age 5 salmon (Table 7). Mean egg weights for hatchery and natural salmon were similar in both Catherine Creek and Upper Grande Ronde River stocks ($P \geq 0.513$). Eggs from natural origin females collected from the Imnaha River, Lookingglass Creek, and the Lostine River were significantly larger than those from hatchery females ($P \leq 0.034$). The largest mean egg weight (0.271 g) was from Imnaha River natural females and the smallest mean egg weight (0.218 g) was from Lookingglass Creek hatchery females. Overall, a greater number of eggs were collected from age 4 (82.2%) than age 5 (17.8%) females and the mean egg weight of age 5 females (0.269 g) was greater than that of age 4 females (0.238 g; $P < 0.001$).

Compensation Goals

Coded-wire tag recovery methods

Hatchery salmon from most production raceways were marked with a coded-wire tag to provide basic information on survival, harvest, escapement, and straying, as well as specific information on experimental groups, if any. Recovery information for each CWT code group was obtained from the Regional Mark Information System (RMIS) CWT recovery database maintained by the Pacific States Marine Fisheries Commission. The RMIS data for this report was current through 28 February 2018.

We compiled observed and estimated numbers of hatchery salmon from each CWT code group recovered in ocean and Columbia River fisheries, as well as strays collected in and out of the Snake River Basin. Estimated CWT recoveries in the RMIS database were expanded from observed recoveries based on sampling efficiencies at some recovery locations, but not for

recoveries observed in the Imnaha and Grande Ronde river basins. Therefore, we estimated total CWT-marked hatchery salmon from each code group (observed from weir collections and spawning ground recoveries) returning to the Imnaha River, Upper Grande Ronde River, Lookingglass Creek, Catherine Creek, and Lostine River based on total escapement to each stream, sampling rate, and the proportion of each cohort marked with CWTs. For some stocks, excess hatchery Chinook Salmon were outplanted to nearby streams. CWTs from these stocks that were recovered in outplant streams were not considered strays and were included in escapement calculations for the stream to which they returned. The methodology for estimating hatchery and natural escapement to the Imnaha River and Grande Ronde Basin streams is described in Feldhaus et al. 2017b Appendix B for detailed methods.

In both the Imnaha and Grande Ronde basins, the exception to the CWT expansion method is when there were no CWT recoveries for a particular brood year, but weir data indicated mature salmon from that brood year had returned. In these cases, we estimated the total number of returning salmon by age class. If the returning salmon from the brood year were potentially comprised of more than one tag group, we partitioned the estimated CWT returns into individual code groups based on the relative proportion of tag group recoveries from the previous year's return.

Calculating returns to the Compensation Area

To assess LSRCP success at achieving mitigation goals and management objectives, we estimated the total numbers of hatchery salmon for each stock that were caught in fisheries, escaped to the stream of release (see Feldhaus et al. 2017b Appendix B for detailed methods), or strayed within or outside the Snake River Basin. To determine the return to the LSRCP Compensation Area, defined as the Snake River Basin above LGD for programs within the State of Oregon, we summed all estimated escapement (harvest, removed at the weir, strays, and all salmon remaining in nature) above LGD for the 2016 return year.

Imnaha River

Coded-wire tag recoveries

A total of 366 hatchery-reared Imnaha River Chinook Salmon with a CWT were recovered from from BYs 2011–2013: 146 CWTs from BY 2013 (age 3), 190 from BY 2012 (age 4), and 30 from BY 2011 (age 5; Table 8). From these CWT recoveries, we estimate that two Imnaha River salmon were harvested in ocean fisheries and 475 were harvested in the Columbia River, where an estimated 229 salmon were harvested in treaty net fisheries, 75 in non-tribal net fisheries, and 171 in sport fisheries. We estimated that seven Imnaha River salmon were harvested in Snake River sport fisheries, and zero were harvested in Snake River tribal fisheries. Below LGD, one stray CWT-marked salmon was recovered in the Deschutes River. Zero stray Imnaha River Chinook Salmon were recovered above Lower Granite Dam.

Within the Imnaha River Basin, we recovered 296 CWT-marked salmon (Table 8). The ODFW estimated that 124 Chinook Salmon were caught (11 CWTs were recovered) in the Imnaha River sport fishery which was open from 15 June – 31 July (Bratcher et al. 2017). The area open to sport fishermen extended from the confluence with the Snake River to Summit Creek Bridge (RKM 72.4). No CWTs were collected from tribal fishers, but NPT and CTUIR reported a total harvest of 162 hatchery salmon (Jack Yearout, NPT, personal communication, 22 March 2017; Preston Bronson, CTUIR, personal communication, 23 November 2016). A total

of 609 mature salmon were removed from the river at the Imnaha River trapping facility. We estimate that 831 mature hatchery salmon remained in nature, 421 above and 410 below the weir.

Return to the Compensation Area and the River

The annual total production goal for mature (ages 3–5) Imnaha River hatchery Chinook Salmon to the mouth of the Columbia River is 16,050 (Corps of Engineers 1974). There is a catch to escapement ratio goal of 4:1, resulting in a harvest mitigation goal of 12,840 mature hatchery Chinook Salmon below LGD and 3,210 mature hatchery salmon to the LSRCP compensation area (above Lower Granite Dam).

For the 2016 return year, we estimated that 2,212 mature (ages 3–5) Imnaha River hatchery Chinook Salmon returned to the Columbia River, 13.8% of the total mitigation goal of 16,050 mature hatchery salmon. We also estimated that 1,733 mature hatchery salmon returned to the LSRCP compensation area, 54.0% of the hatchery compensation goal (3,210) for the Imnaha River stock (Table 8). Of the total escapement above Lower Granite Dam, we estimated that 293 mature hatchery salmon were harvested in fisheries, 9.1% of the compensation area mitigation goal. We estimated 477 mature Imnaha River hatchery Chinook Salmon were harvested in fisheries below Lower Granite Dam, 3.7% of the downstream harvest mitigation goal.

We estimated that 1,726 hatchery and 756 natural origin salmon returned to the Imnaha River in 2016. The estimated total return to the river of hatchery salmon was comprised of 297 age 3, 1,240 age 4, and 188 age 5 returns. For natural salmon, we estimated that 45 age 3, 549 age 4, and 162 age 5 returned. The combined sport and tribal harvest of 286 hatchery Chinook Salmon represents 16.5% of the estimated total return of mature hatchery salmon to the Imnaha River.

Recruits:Spawner (R:S) and Smolt-to-Adult Return Rates (SAR)

Recruits-per-spawner (R:S) ratios reported here include jacks. The R:S ratio for the hatchery component was calculated by dividing the total return by the number of parents (ages 3–5) spawned at Lookingglass Fish Hatchery to produce those recruits. The R:S ratio for salmon that spawned in nature was calculated by dividing the total return of mature (ages 3–5) salmon that returned to the mouth of the Imnaha River by the estimated number of mature hatchery and natural origin salmon that spawned naturally in the river. Estimates of salmon spawning in nature were adjusted for pre-spawn mortality of the parents. The R:S ratio for BY 2011 was 18.4 for those spawned in the hatchery (any origin) and 0.4 for those spawned in nature (Figure 2). The BY 2011 smolt-to-adult return rate (SAR) for hatchery salmon that returned to the mouth of the Imnaha River was 1.206% (Table 9). Natural smolt numbers were not available to estimate SAR rates for BY 2011.

Grande Ronde Basin

Catherine Creek coded-wire tag recoveries

We recovered 85 hatchery-reared Catherine Creek Chinook Salmon with a CWT from BYs 2011–2013: 22 from BY 2013 (age 3), 61 from BY 2012 (age 4), and two from BY 2011 (age 5; Table 10). Zero Catherine Creek Chinook Salmon were recovered in ocean fisheries. We estimated that 62 salmon were harvested in the Columbia River: 28 in tribal net fisheries, 10 in non-tribal net fisheries, and 24 in sport fisheries. In the Snake River, we estimated that three Catherine Creek salmon were harvested in sport fisheries, and zero in tribal fisheries. No CWT-

marked Catherine Creek salmon were recovered as strays below LGD. Above LGD, zero CWT-marked salmon were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, we recovered 15 stray Catherine Creek salmon that we estimated to represent 45 mature salmon (Table 10). Twelve stray CWT-marked Catherine Creek salmon were recovered in Lookingglass Creek (two on the spawning grounds, one from the sport fishery, and nine from the weir). One stray was recovered from spawning ground surveys on Hurricane Creek and two were recovered in the Lostine River (one on spawning surveys and one at the trap). Within Catherine Creek, 60 CWT-marked salmon were recovered. A total of 75 mature hatchery salmon were removed from the river at the Catherine Creek weir. We estimated that 196 were on the spawning grounds above the weir, and five were below the weir.

Upper Grande Ronde River coded-wire tag recoveries

We recovered 238 hatchery-reared Upper Grande Ronde River Chinook Salmon with a CWT from BYs 2011–2013: 25 from BY 2013 (age 3), 193 from BY 2012 (age 4), and 20 from BY 2011 (age 5; Table 11). From these recoveries, we estimated that zero were caught in ocean fisheries, 147 were caught in the Columbia River, and four were caught in the Snake River. Below Lower Granite Dam, zero stray CWT-marked salmon were recovered. Above LGD, and outside the Grande Ronde basin, zero CWT-marked salmon were recovered.

Within the Grande Ronde Basin, 86 CWT-marked salmon were recovered as in-basin strays that were estimated to represent 155 strays, 34% of the total return of Upper Grande Ronde Chinook Salmon to the Grande Ronde Basin. We recovered 85 of the 86 of the CWT-marked in-basin stray salmon in Lookingglass Creek (26 from the spawning grounds and 59 from the salmon trap). A total of 123 mature hatchery salmon were removed from the river at the Upper Grande Ronde River salmon weir. We estimated that 171 were on the spawning grounds above the weir, and zero were below the weir.

Lookingglass Creek coded-wire tag recoveries

We recovered 265 hatchery-reared Chinook Salmon released into Lookingglass Creek with a CWT from BYs 2011–2013: 55 from BY 2013 (age 3), 196 from BY 2012 (age 4), and 14 from BY 2011 (age 5; Table 12). Zero Lookingglass Creek salmon were caught in ocean fisheries. In the Columbia River, we estimated that 195 mature salmon were recovered: 51 in treaty net fisheries, 23 in non-tribal net fisheries, and 121 in sport fisheries. We estimated that 15 mature hatchery salmon were harvested in Snake River sport fisheries. Below LGD, one CWT-marked salmon was recovered at Pelton Dam on the Deschutes River. Above LGD and outside the Grande Ronde Basin, zero stray CWT-marked salmon from Lookingglass Creek were recovered.

Above LGD and within the Grande Ronde Basin, three CWT-marked salmon were recovered: one in the Wenaha River and two in the Lostine River (one on spawning surveys and one at the trap; Table 12). These three in-basin CWT stray recoveries expanded to 15 salmon. Within Lookingglass Creek, 228 CWT-marked salmon were recovered. We recovered zero CWTs from Lookingglass Creek hatchery salmon in the Lookingglass Creek sport fishery. A total of 241 mature Lookingglass Creek hatchery salmon were removed from the river at the Lookingglass Creek salmon trap. We estimated that 347 were on the spawning grounds above the weir and 232 were below the weir.

Lostine River coded-wire tag recoveries

We recovered 152 hatchery-reared Chinook Salmon released into the Lostine River with a CWT from BYs 2011–2013: 14 CWTs from BY 2013 (age 3), 115 from BY 2012 (age 4), and 23 from BY 2011 (age 5; Table 13). We estimated that five mature Lostine River Chinook Salmon were caught in ocean fisheries. In the Columbia River we estimated that 137 were recovered in tribal net fisheries, 34 in non-tribal net fisheries, and 103 in sport fisheries. Below LGD, three CWT-marked salmon were recovered in the Deschutes River at the Round Butte Trap. Within the Snake River above LGD, zero CWT-marked salmon were recovered in sport or tribal fisheries, and zero CWT-marked salmon were recovered outside the Grande Ronde Basin.

Within the Grande Ronde Basin, two CWT-marked Lostine River salmon were recovered on spawning surveys in Hurricane Creek and three were recovered on spawning surveys in the Wallowa River (Table 13). These five CWT recoveries were expanded to represent 27 in-basin stray salmon. Within the Lostine River, 108 CWT-marked salmon were recovered. A total of 256 mature hatchery salmon were removed from the river at the Lostine River salmon trap. We estimated that 571 were on the spawning grounds above the weir and 138 were below the weir.

Return to the Compensation Area and the River

The annual total production goal of mature hatchery Chinook Salmon to the mouth of the Columbia River for the Grande Ronde Basin is 29,300 (Corps of Engineers 1975). We estimated that total production in 2016 was 3,548, 12.1% of the total adult production goal (Tables 10-13). For the Columbia River Basin below Lower Granite Dam there is a catch to escapement ratio goal of 4:1, resulting in a harvest mitigation goal of 23,440 hatchery Chinook Salmon. We estimated 683 Grande Ronde Basin hatchery salmon were harvested in fisheries below Lower Granite Dam, 2.9% of the downstream mitigation goal (Tables 10-13). Harvest below Lower Granite Dam was comprised of an estimated 62 Catherine Creek, 147 Upper Grande Ronde River, 195 Lookingglass Creek, and 279 Lostine River hatchery Chinook Salmon.

In the Grande Ronde Basin, the annual compensation goal for all stocks combined was set at 5,860 mature hatchery salmon (Herrig 1990). We estimated that 324 Catherine Creek, 455 Upper Grande Ronde River, 956 Lookingglass Creek, and 1,124 Lostine River mature hatchery Chinook Salmon returned to the compensation area, a combined return of 2,859 hatchery salmon, 48.8% of the compensation goal (Tables 10-13).

We determined that the returns to Catherine Creek in 2016 were comprised of 44 age 3, 215 age 4, and 17 age 5 hatchery salmon (Table 10) and 10 age 3, 228 age 4, and 28 age 5 natural salmon (ODFW, unpublished data). There were no sport or tribal fisheries in Catherine Creek.

We estimated that 24 age 3, 247 age 4, and 25 age 5 hatchery salmon (Table 11) and 11 age 3, 81 age 4, and six age 5 natural salmon (ODFW, unpublished data) returned to the Upper Grande Ronde River in 2016. There were no sport fisheries in the Upper Grande Ronde River. Tribal fishers reported harvest of two hatchery salmon (Preston Bronson, CTUIR, personal communication, 23 November 2016).

After removing known hatchery strays recovered in Lookingglass Creek, we estimated that the 2016 returns of mature hatchery salmon released as smolts into Lookingglass Creek were comprised of 152 age 3, 720 age 4, and 53 age 5 hatchery (Table 12). Additionally, we estimated that seven age 3, 401 age 4, and 24 age 5 natural salmon returned to Lookingglass Creek in 2016 (ODFW, unpublished data). CTUIR tribal harvest estimates were zero hatchery jacks, 15 hatchery adults, zero natural origin jacks, and four natural origin adult (Preston

Bronson, CTUIR, personal communication, 23 November 2016). NPT tribal harvest estimates were zero hatchery jacks, 44 hatchery adults, zero natural jacks, and 11 natural adults (Jack Yearout, NPT, personal communication, 22 March 2017). The sport fishery was open from 28 May – 31 May 2016 and extended 3.2 kilometers upstream from the Lookingglass Creek mouth at the Moses Creek Lane Bridge upstream to the confluence of Jarboe Creek (Bratcher et al. 2017). Sport fishery harvest estimates were four hatchery jacks and 44 hatchery adults. Additionally, ODFW estimated that zero natural origin jacks and 22 natural origin adults were released by sport anglers.

We estimated that 174 age 3, 784 age 4, and 137 age 5 hatchery (Table 13) and 21 age 3, 529 age 4, and 117 age 5 natural salmon (ODFW, unpublished data) returned to the Lostine River in 2016. The CTUIR tribal harvest estimates were 0 hatchery jacks, 14 hatchery adults, zero natural origin jacks, and five natural origin adults (Preston Bronson, CTUIR, personal communication, 23 November 2016). NPT tribal harvest estimates were four hatchery jacks, 144 hatchery adults, zero natural jacks, and 18 natural adults (Jack Yearout, NPT, personal communication, 22 March 2017). The Wallowa River sport fishery was open from the Minam State Park upstream to the mouth of the Lostine River (27.4 RKM). The ODFW estimated that zero Chinook Salmon were caught or harvested in this fishery (Bratcher et al. 2017).

The 2016 Chinook Salmon returns of Grande Ronde Basin hatchery salmon failed to meet either the compensation area mitigation or total adult production goals. Similar to previous years, harvest of hatchery salmon in the Grande Ronde Basin is hindered by the paucity of natural salmon and the threat of incidental hooking mortality, lack of fishing access in some streams, and seasonally poor river conditions for angling (e.g., high discharge and turbid water in the Wallowa River). Of the total escapement above Lower Granite Dam, we estimated that 244 hatchery salmon were harvested in sport and tribal fisheries, 4.2% of the compensation area return. Factors that have previously contributed to low hatchery returns of Grande Ronde Basin hatchery salmon included low numbers of CHP broodstock collections and limited rearing space at Lookingglass Fish Hatchery (Hoffnagle et al. 2003; Carmichael et al. 2007). Consistently poor smolt migration survival (<50%) from Catherine Creek and Upper Grande Ronde River acclimation sites to LGD is another factor that has also been identified as contributing to reduced hatchery returns (this report and Monzyk et al. 2009).

Recruits:Spawner (R:S) and Smolt-to-Adult Return (SAR) Rates

We calculated R:S ratios for both the hatchery and natural components using estimates of recruits returning to the confluence of the terminal tributary (mouth) within the Grande Ronde River Basin. The R:S ratio for the hatchery component was calculated by dividing the number of mature offspring (ages 3-5) that return to the tributary mouth into which they were released by the number of parents (ages 3-5) spawned at Lookingglass Fish Hatchery to produce those recruits. The R:S ratio for salmon that spawned in nature was calculated by dividing the number of mature salmon returns to the tributary mouth (ages 3-5) by the estimated number of mature hatchery and natural origin salmon that spawned naturally in the river, adjusted for pre-spawn mortality of the parents.

In Catherine Creek, the R:S ratio for BY 2011 was 6.8 for the CHP hatchery component and 0.2 for the natural component. The BY 2011 SAR rate to the mouth of Catherine Creek for the CHP program was 0.382% (Table 14).

In the Upper Grande Ronde River, the R:S ratios for the CHP hatchery and natural components from the 2011 brood year were 14.7 and 0.3, respectively. The BY 2011 SAR rate

for CHP and CBS hatchery salmon that returned to the Upper Grande Ronde River was 0.880% and 0.313%, respectively (Table 15). The BY 2011 CBS returns were the last returns of CBS hatchery salmon from that program in the Grande Ronde Basin.

In Lookingglass Creek, the R:S ratios for the hatchery and natural components from BY 2011 were 10.8 and 0.4, respectively. The SAR rate to the mouth of Lookingglass Creek for BY 2011 returns of CHP smolts released into Lookingglass Creek was 0.584% (Table 16).

In the Lostine River, the R:S ratios for BY 2011 were 20.3 and 0.1 for CHP hatchery and natural returns, respectively. The SAR rates to the mouth of the Lostine River for BY 2011 CHP production smolts released into the Lostine River was 0.945% (Table 17).

Escapement Monitoring

We conducted spawning ground surveys on three streams in the Imnaha Basin and 11 in the Grande Ronde Basin. Stream surveys to count Chinook Salmon redds and sample salmon carcasses were conducted as in previous years (see Monzyk et al. 2006a).

In 2016, we counted 481 redds and recovered 319 carcasses in the Imnaha Basin (Table 18). The number of redds/river kilometer (rkm) in 2016 (5.7 redds/rkm) was lower than 2015 when 7.4 redds/rkm were observed (Figure 3). With an estimated 756 mature natural salmon returning to the Imnaha River Basin, 2016 is the 16th year since the first year of hatchery returns (1985) with >500 mature natural origin salmon returning to the Imnaha River (Figure 4). Hatchery salmon comprised 49.0% of known origin carcasses recovered on spawning ground surveys in the Imnaha River Basin (Table 18). Adult (age 4-5) hatchery salmon returns to the Imnaha River have exceeded natural adult returns for the last 20 consecutive years and 24 of the 32 years that hatchery salmon have returned to the Imnaha River. On two tributary streams to the Imnaha River, Big Sheep Creek and Lick Creek, nine hatchery, five natural origin carcasses were recovered. We did not recover any out-of-basin hatchery strays in the Imnaha River basin (Table 19).

In the Grande Ronde Basin, we counted 1,417 redds and recovered 942 carcasses (Table 18). The number of redds/rkm in 2016 (6.5 redds/km) was the same as 2015 (Figure 3). Hatchery salmon comprised the majority (51.8%) of known origin carcasses recovered on spawning ground surveys in the Grande Ronde Basin. Unlike 2015, no mature salmon from the Upper Grande Ronde River Safety Net Program (SNP) were released into the Grande Ronde Basin. Mature hatchery Chinook Salmon have comprised the majority of returns in 13 of the last 16 return years in Catherine Creek, 13 of the last 15 return years in the Upper Grande Ronde River, 15 of the last 16 return years in the Lostine River, and 12 of the last 13 years in Lookingglass Creek.

In the Grande Ronde Basin, we recovered 42 in-basin strays: one Catherine creek and five Lostine River salmon in Hurricane Creek; two Catherine Creek and 26 Upper Grande Ronde River salmon in Lookingglass Creek; one Catherine Creek and one Lookingglass Creek salmon in the Lostine River; one Upper Grande Ronde River and four Lostine River salmon in the Wallowa River; and one Lookingglass Creek salmon in the Wenaha River (Table 19). We did not recover any hatchery salmon in the Minam River. Additionally, we recovered two out-of-basin stray hatchery salmon. One out-of-basin stray, recovered in Lookingglass Creek, had a CWT code that indicated it was a Fall Chinook Salmon which was reared at Priest Rapids

Hatchery (WA) and released into the Columbia River at Priest Rapids. The second out-of-basin stray, recovered in the Wenaha River, was reared at the Umatilla River Fish Hatchery and released into the Umatilla River, OR.

Of the nine Lostine River CWT codes recovered in Hurricane Creek and the Wallowa River, four were from salmon with hole punches in the opercle plate (OP). The OP punch indicated that these salmon were captured at the Lostine River weir and then placed into the Wallowa River for either added fishing opportunities for sport and tribal fishers or for natural spawning to limit the number of hatchery salmon placed above the Lostine River weir (Table 5). In 2016, 40 CWT's were recovered in the Grande Ronde Basin from salmon released into the Upper Grande Ronde River. Sixty-five percent (N = 26) of those CWT's were recovered in Lookingglass Creek. Additionally, of the 135 CWT's recovered in Lookingglass Creek, 19.2% were from salmon released into the Upper Grande Ronde River.

In Grande Ronde Basin streams with hatchery supplementation, estimates of Chinook Salmon spawning in nature have been largely and consistently comprised of hatchery salmon (Figure 5). The percentage of known hatchery salmon recovered on spawning ground surveys was 35.7% in Catherine Creek, 83.3% in the Upper Grande Ronde River, 66.2% in Lookingglass Creek, 53.0% in the Lostine River (Table 18). In the two wilderness streams, the Minam River and the Wenaha River, the composition of hatchery salmon on the spawning grounds was 0% and 16.7%, respectively.

Pre-spawn Mortalities

We visually examined female Chinook Salmon carcasses sampled on the spawning grounds for egg retention. We classified females as a pre-spawn mortality (PSM) if $\geq 50\%$ of the eggs were retained and spawned if $< 50\%$ of the eggs were retained. If we could not determine egg retention for a female carcass, it was not included in the calculation of PSM. We do not estimate spawning success for male carcasses and assume that the PSM rate for males is the same as that of females. The PSM rate is calculated by dividing the number of PSM females by the total number of identifiably spawned and unspawned females. For streams with weirs (i.e., hatchery supplementation programs), our preference is to estimate PSM rates above and below weirs separately. If we recover < 20 females above or below a weir, we combine above and below weir recoveries to calculate a single PSM rate estimate for the stream. For the Wallowa-Lostine populations (i.e., the Lostine River, Bear Creek, Hurricane Creek, and Wallowa River), we calculated a combined annual PSM rate estimate. In the Minam and Wenaha rivers, we seldom recover 20 female carcasses, and when we do recover ≥ 20 females, the estimated mortality rates are $< 10\%$. We are currently reviewing methods for estimating PSM rates (e.g., Bowerman et al. 2016) and have a goal of revising our standards for monitoring and applying PSM data in our program.

Except for Lookingglass Creek and the Lostine River, fewer than 20 female carcasses were recovered where egg retention could be estimated, and only 14 pre-spawn mortalities were recovered (Table 20). The PSM rates in Lookingglass Creek and the Lostine River were 4.9% and 21.9%, respectively. Based on 19 female carcasses, the PSM rate in the Imnaha River was 15.8%. We recovered 12 female carcasses in Catherine Creek, one in the Upper Grande Ronde, zero in the Minam River and six in the Wenaha River. None of the females recovered in Catherine Creek, the Upper Grande Ronde River, the Minam River, or the Wenaha River were

pre-spawn mortalities. These PSM rates should be considered minimums because the data were mostly collected from carcasses sampled during active spawning and any females that may have died well before the first survey would not be recovered.

Coordinated Assessments

To facilitate standardized reporting to the National Oceanic and Atmospheric Administration (NOAA) Fisheries division, we provide annual updates of population level trend data for natural origin Chinook Salmon to the regional Coordinated Assessments (CA) data exchange (<http://cax.streamnet.org/>). The indicators reported on the CA website include Natural Origin Spawner Abundance, Recruits:Spawner, Smolt-to-Adult Return rates, and estimates of juvenile out-migrants. Detailed methods and data analysis flow diagrams showing how each metric is calculated, including the source data, are under development and will be posted at a future date on <http://nrimp.dfw.state.or.us/DataClearinghouse/>.

Acknowledgments

The Lookingglass Fish Hatchery personnel exhibited great dedication and provided essential assistance. Numerous employees from the ODFW, U.S. Fish and Wildlife Service, U.S. Forest Service, Nez Perce Tribe (NPT), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and Grande Ronde Model Watershed were supportive during spawning ground surveys and spawning at Lookingglass Fish Hatchery. The NPT provided Lostine River weir data and CTUIR provided weir data from Catherine Creek and the Upper Grande Ronde River, as well as spawning ground survey data summarized from Lookingglass Creek. This project was funded by the U.S. Fish and Wildlife Service under the Lower Snake River Compensation Plan, contract number F16AC00030, a cooperative agreement with ODFW.

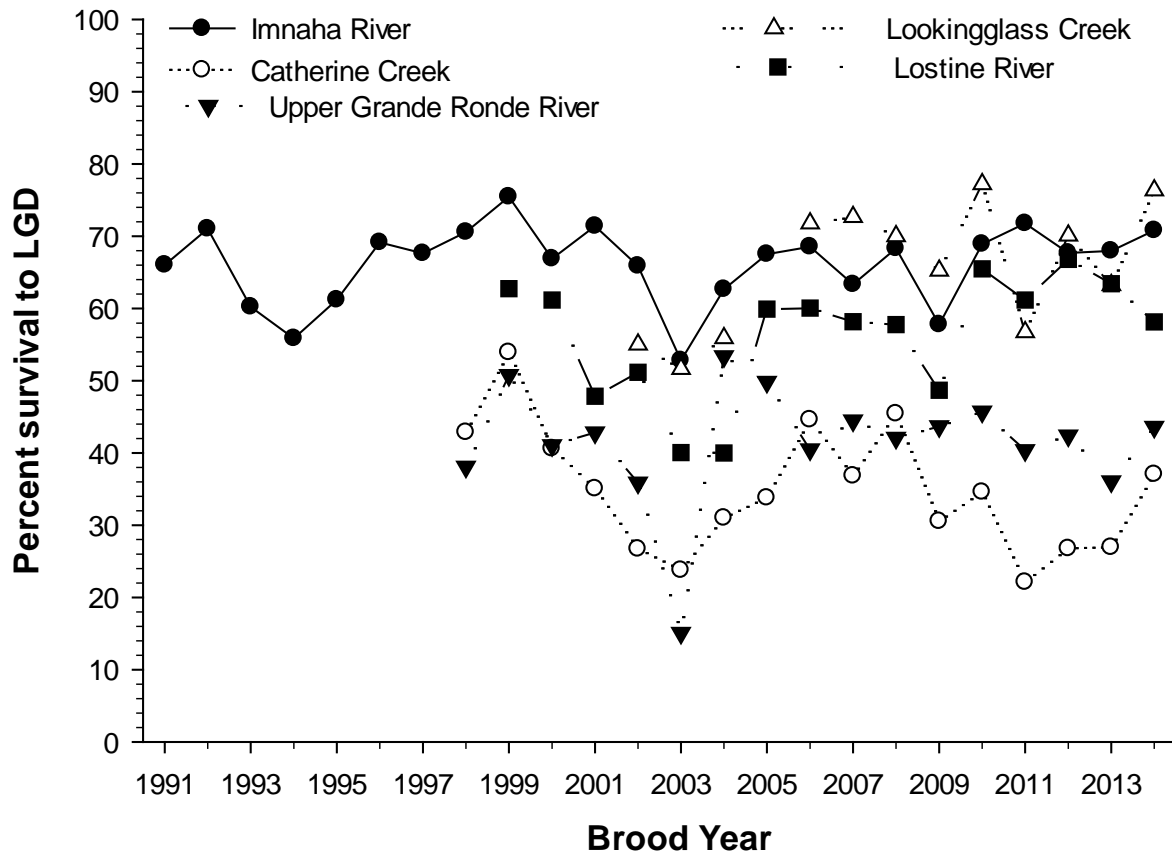


Figure 1. Mean survival rates to Lower Granite Dam (LGD) of PIT-tagged Chinook Salmon smolts released into the Imnaha River, Catherine Creek, Upper Grande Ronde River, Lookingglass Creek, and Lostine River, BYs 1991-2014.

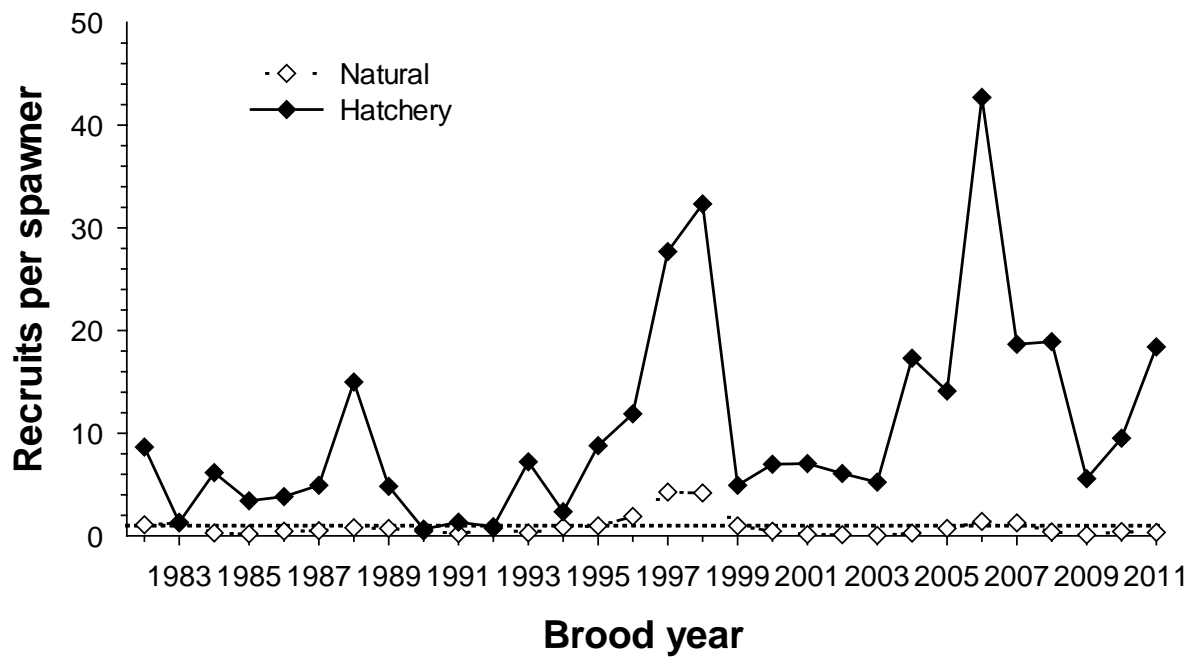


Figure 2. Total (including jacks) recruits-per-spawner ratios for completed brood years of Innaha River Chinook Salmon, BYs 1982–2011. Note: dotted line indicates recruits-per-spawner ratio=1.

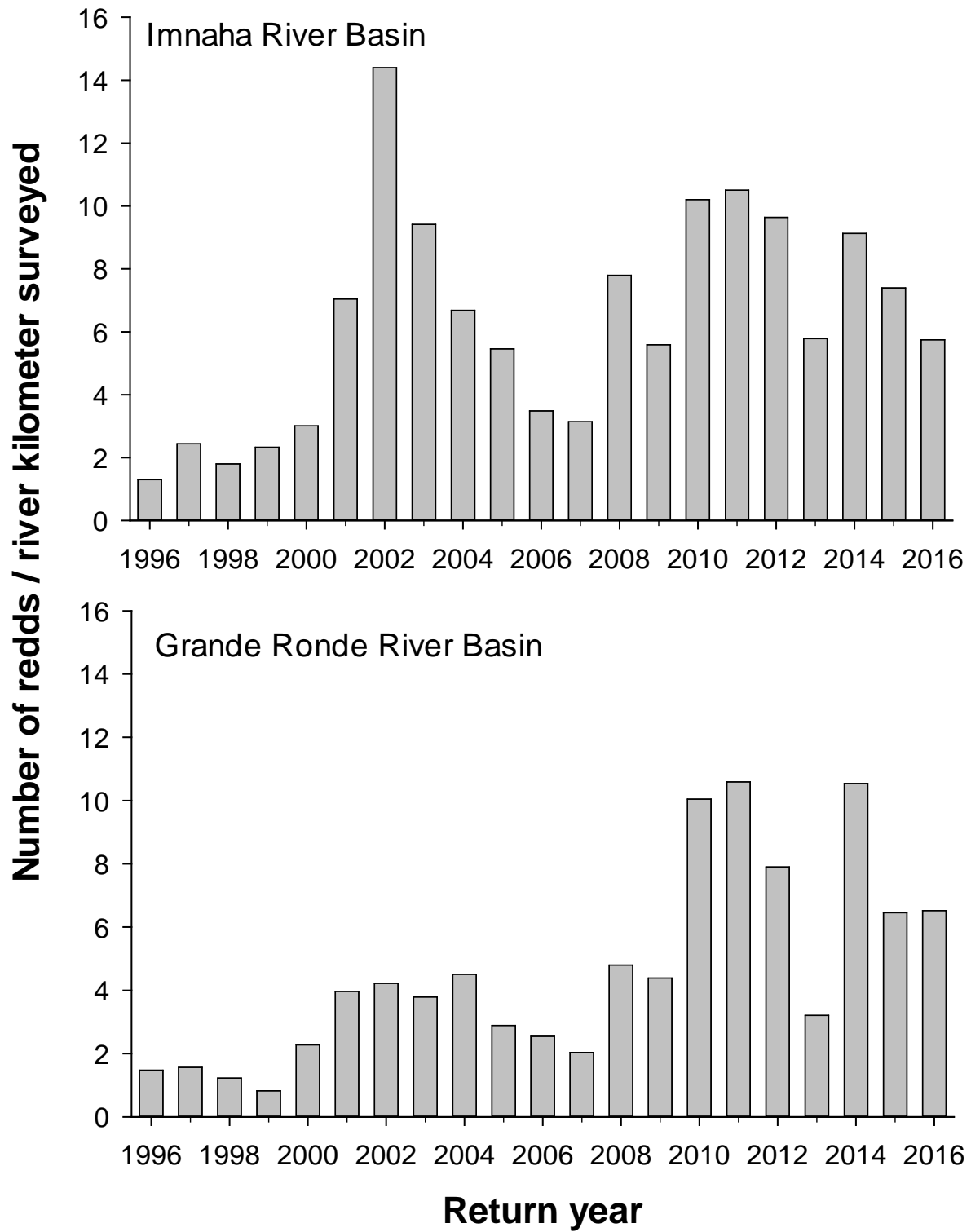


Figure 3. Total redds/river kilometer surveyed in the Imnaha and Grande Ronde river basins, 1996-2016.

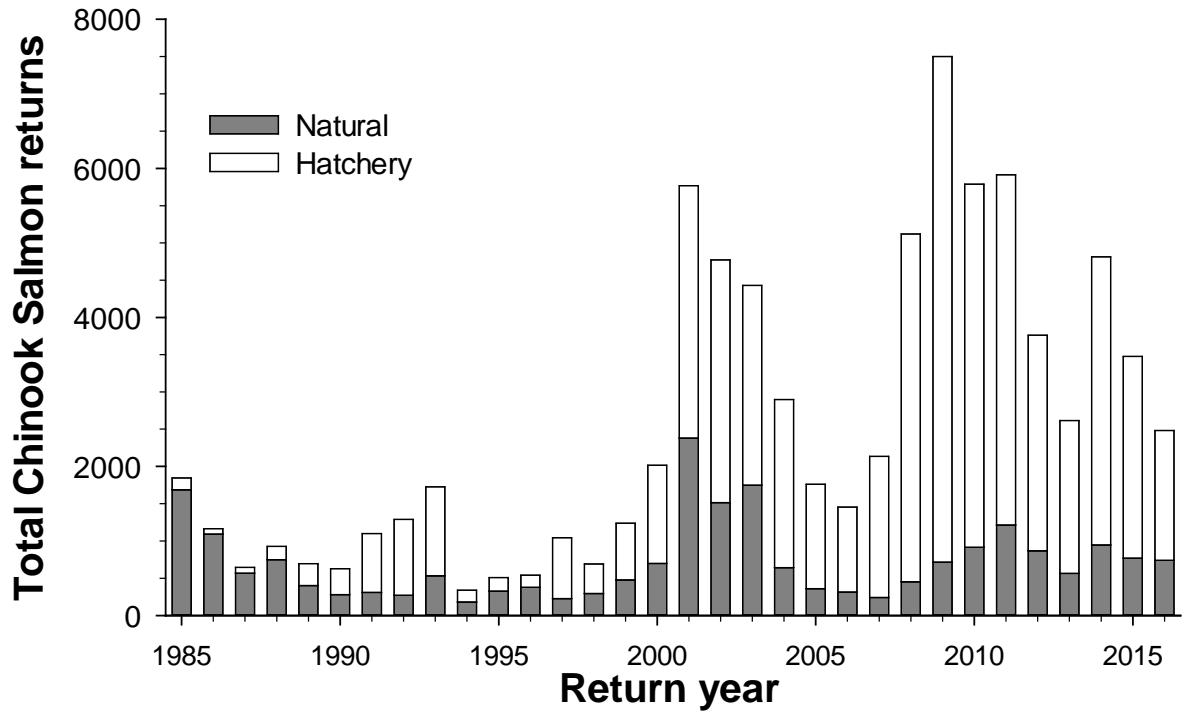


Figure 4. Estimated numbers of mature (ages 3-5) natural- and hatchery-origin Chinook Salmon that returned to the Imnaha River, 1985-2016.

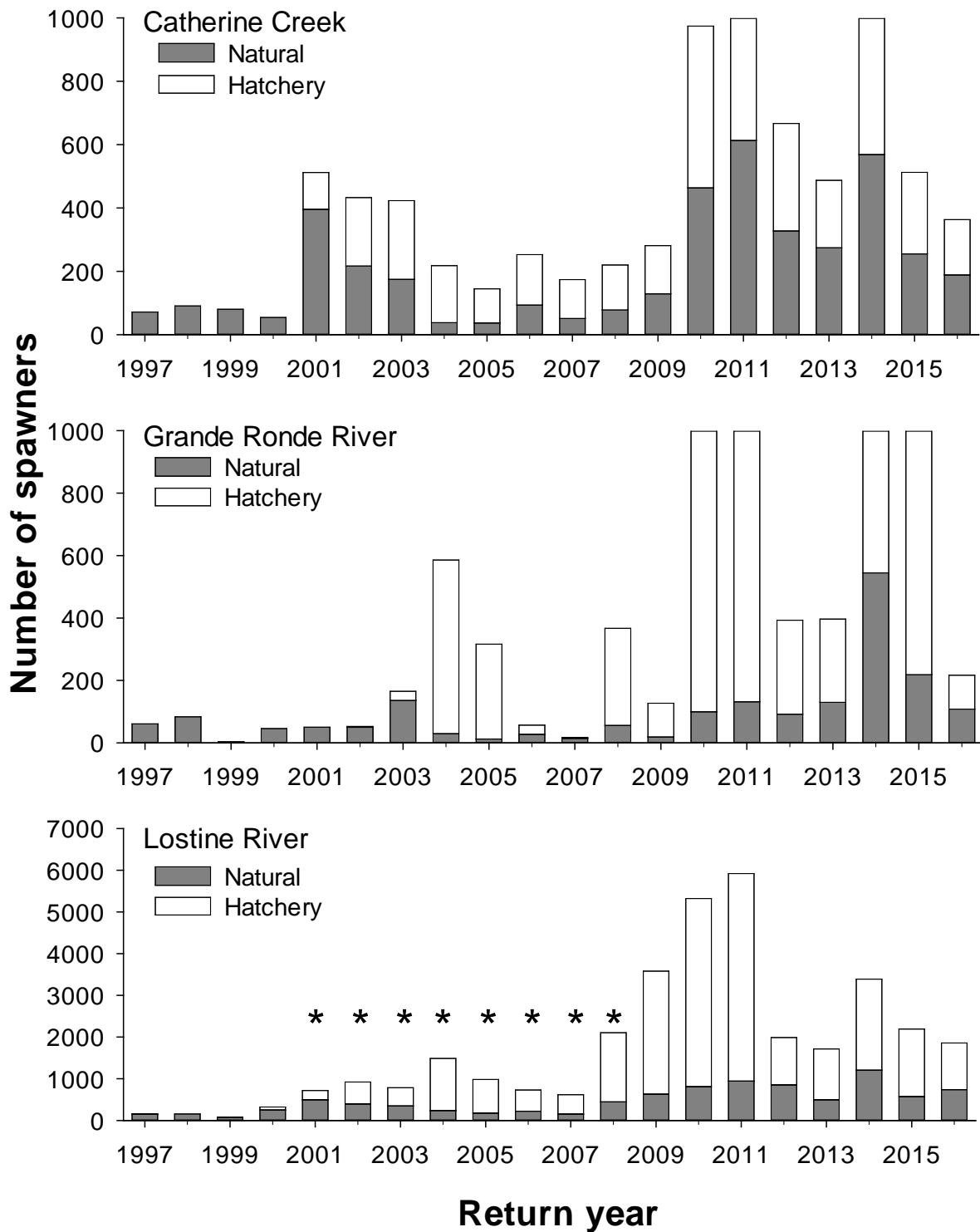


Figure 5. Estimated numbers of mature (ages 3-5) natural- and hatchery-origin Chinook Salmon that spawned naturally in Catherine Creek, Upper Grande Ronde River, and Lostine River, 1997-2016. *Lostine River data from 2001–2008 are not reliable because the Nez Perce Tribe reported that some members of the hatchery production staff falsified weir data.

Table 1. Production summaries for BY 2014 juvenile spring Chinook Salmon from the Conventional Hatchery Program released into the Imnaha and Grande Ronde river basins, 2016.

Stock	Number of females spawned	Number of green eggs taken	Eyed eggs	Number of eggs culled ^a	Number released as eyed eggs	Percent Survival			Total smolts released	Smolt release goal
						Green egg-to-eyed egg	Eyed egg-to-smolt ^b	Green egg-to-smolt ^b		
Imnaha River	140	621,831	586,293 ^c	8,842	0	94.3	89.7	84.5	516,802	490,000
Catherine Creek	44	188,435	174,568	4,259	0	92.6	97.3	90.0	165,739	150,000
Upper Grande Ronde River ^d	68	268,027	253,495	2,944	0	94.5	95.9	90.7	240,332	250,000
Lookingglass Creek	82	324,484	312,682	0	0	96.4	96.8	93.3	302,589	250,000
Lostine River	74	314,769	295,673	12,407	0	93.9	91.2	85.4	258,267	250,000

^a Eggs were culled if enzyme-linked immunosorbent assay (ELISA) levels of female broodstock were > 0.2 for CHP production.

^b Embryos culled from production, released as eyed eggs, or transferred to another facility were subtracted from the calculation of green egg-to-smolt and eyed egg-to-smolt survival.

^c 1,500 Imnaha stock eyed eggs (150 from each of 10 females) were transferred to NOAA's Manchester Research Station for a jacking study.

^d An overage (more fish than expected, based on egg counts) of 10,321 Upper Grande Ronde River juveniles was recorded in August 2015; thus, the original green and eyed egg counts have been updated by the addition of 10,321 to each.

Table 2. Estimates of percent adipose fin (Ad) clip and coded-wire tag (CWT) application success for BY 2014 spring Chinook Salmon smolts produced from the Conventional Hatchery (CHP) program at Lookingglass Fish Hatchery and released in 2016.

Stock	Number of Raceways	% Ad clip, with CWT	% Ad clip, no CWT		% CWT, no Ad clip	% CWT, no Ad clip	Total smolts released
			% Ad clip, no CWT	% Ad clip, no CWT			
Imnaha River	6	58.7	36.3	3.1	1.9	516,802	
Catherine Creek	2	67.6	32.4	0.0	0.0	165,739	
Upper Grande Ronde R.	4	47.4	1.9	48.7	2.0	240,332	
Lookingglass Creek	3	46.3	52.2	0.0	1.5	302,589	
Lostine River	3	51.4	46.5	0.0	2.1	258,267	
<i>Total</i>	<i>18</i>					<i>1,483,729</i>	

Table 3. Release dates, mean size, total number of coded-wire-tagged smolts and total number of smolts, number PIT-tagged, and survival rate to Lower Granite Dam of BY 2014 Conventional Hatchery Program spring Chinook Salmon smolts released into the Imnaha and Grande Ronde river basins, 2016. Fork length and weight data were collected at Lookingglass Fish Hatchery, 8-10 February 2016.

Stock, CWT code	Raceway	Release dates		Fork Length (mm)		Weight (g)		CWT- marked smolts	Total smolts released	Number PIT- tagged	Survival rate to Lower Granite Dam
		Volitional	Forced	Mean	SD	Mean	SD				
<u>Imnaha River</u>											
090959	4	<i>a</i>	13 APR	112.3	7.3	16.7	3.3	80,047	84,410	3,475	0.72
090960	5	<i>a</i>	13 APR	109.4	7.4	16.8	3.1	78,959	83,527	3,498	0.69
090961	6	1 APR	7 APR	112.8	8.9	17.3	3.5	82,642	85,666	3,487	0.73
090962	7	1 APR	7 APR	110.1	7.7	15.8	3.6	77,832	85,548	3,502	0.76
Ad-only	8	1 APR	7 APR	108.9	8.4	15.4	3.2	0	89,504	3,493	0.70
<u>Ad-only</u>	9	1 APR	7 APR	108.0	7.6	15.4	3.2	<u>0</u>	<u>88,147</u>	<u>3,495</u>	<u>0.64</u>
Total/mean								319,480	516,802	20,950	0.71
<u>Catherine Creek</u>											
090955	1	23 MAR	14 APR	110.7	10.3	13.9	3.1	56,435	81,903	10,415	0.36
<u>090956</u>	2	23 MAR	14 APR	109.8	9.1	16.3	3.8	<u>55,683</u>	<u>83,836</u>	<u>10,401</u>	<u>0.38</u>
Total/mean								112,118	165,739	20,816	0.37
<u>Upper Grande Ronde River</u>											
090951	15	21 MAR	5 APR	109.0	8.2	16.2	3.7	58,305	61,054	496	0.43
090949	16	21 MAR	5 APR	108.2	8.4	15.1	3.3	56,778	59,023	496	0.42
090952	17	8 APR	18 APR	107.2	8.3	14.8	3.7	57,985	60,120	497	0.45
<u>090950</u>	18	8 APR	18 APR	108.9	8.1	16.5	4.6	<u>57,868</u>	<u>60,135</u>	<u>499</u>	<u>0.45</u>
Total/mean								230,936	240,332	1,988	0.44

Table 3 continued.

Stock, CWT code	Raceway	Release dates		Fork Length (mm)		Weight (g)		CWT- marked smolts	Total smolts released	Number PIT- tagged	Survival rate to Lower Granite Dam
		Volitional	Forced	Mean	SD	Mean	SD				
<u>Lookingglass Creek</u>											
Ad-only	3	1 APR	11 APR	111.2	8.6	15.8	3.2	0	103,755	1,654	0.78
090957	10	1 APR	11 APR	112.5	10.0	16.6	4.6	69,069	94,916	1,628	0.78
090958	14	1 APR	11 APR	110.0	9.1	14.8	3.3	<u>70,895</u>	<u>103,918</u>	<u>1,687</u>	<u>0.73</u>
Total/mean								139,964	302,589	4,969	0.76
<u>Lostine River</u>											
Ad-only	11 ^b	21 MAR	20 APR	108.1	8.5	15.4	3.8	0	87,034	807	0.60
090953	12	21 MAR	31 MAR	110.9	6.9	16.7	3.1	66,501	86,087	796	0.54
090954	13	12 APR	20 APR	107.8	8.1	14.0	3.6	<u>66,258</u>	<u>85,146</u>	<u>800</u>	<u>0.61</u>
Total/mean								132,759	258,267	2,403	0.58

^a Direct stream release at the Imnaha River weir.

^b Raceway 11 was split between early and late acclimation. Approximately 40,849 smolts were released during the early acclimation (3/21/2016 – 3/31/2016) and 43,462 were released during the late acclimation (4/12/2016 – 4/20/2016).

Table 4. Numbers of mature spring Chinook Salmon handled each week at northeast Oregon LSRCP trapping facilities in 2016. Totals for each stream exclude recaptured salmon. Total for Lookingglass Creek includes stray hatchery salmon from the Catherine Creek and Upper Grande Ronde River stocks, and excludes outplants from Catherine Creek. These numbers were not adjusted to account for unmarked hatchery returns.

Period	Week of year	Imnaha River ^a		Catherine Creek ^b		Upper Grande Ronde River ^b		Lookingglass Creek ^a		Lostine River ^c	
		Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural
Dates of trap operation:		16 MAY – 9 SEP		1 MAR – 5 AUG		1 MAR – 3 JUN		1 MAR – 15 SEP		15 FEB – 27 SEP	
17 – 23 APR	17	-	-	0	0	0	0	0	0	0	0
24 APR – 30 APR	18	-	-	0	0	0	0	0	0	0	0
1 – 7 MAY	19	-	-	0	0	0	0	0	0	0	0
8 – 14 MAY	20	0	0	0	0	0	0	1	0	0	0
15 – 21 MAY	21	0	0	1	2	0	0	5	4	0	0
22 – 28 MAY	22	0	0	3	11	31	15	0	2	0	0
29 May – 4 JUN	23	0	0	101	132	197	53	157	103	0	1
5 – 11 JUN	24	0	0	93	62	-	-	173	152	2	2
12 – 18 JUN	25	1	2	25	11	-	-	49	29	1	1
19 – 25 JUN	26	188	85	30	32	-	-	120	32	13	9
26 JUN – 2 JUL	27	157	77	17	10	-	-	53	10	6	12
3 – 9 JUL	28	155	51	0	0	-	-	4	3	15	9
10 – 16 JUL	29	100	41	0	0	-	-	12	2	122	80
17 – 23 JUL	30	207	92	0	0	-	-	2	1	226	156
24 JUL – 30 JUL	31	148	40	0	0	-	-	1	0	66	44
31 JULY – 6 AUG	32	34	12	0	1	-	-	0	0	13	10
7 – 13 AUG	33	24	11	-	-	-	-	3	1	7	5
14 – 20 AUG	34	106	53	-	-	-	-	9	5	23	25
21 – 27 AUG	35	42	41	-	-	-	-	12	2	47	31
38 AUG – 3 SEP	36	26	18	-	-	-	-	15	3	126	119
4 – 10 SEP	37	1	4	-	-	-	-	8	1	19	27
11 – 17 SEP	38	-	-	-	-	-	-	2	0	2	10
Total		1,189	527	270	261	228	68	626	350	688	541

^a Operated by the Oregon Department of Fish and Wildlife

^b Operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Data provided by Mike McLean (CTUIR).

^c Operated by Nez Perce Tribe (NPT). Data provided by Peter Cleary and Shane Vatland (NPT).

Table 5. Numbers and dispositions, by origin, age, and sex of mature spring Chinook Salmon returning to northeast Oregon LSRCP trapping facilities in 2016. Numbers of Chinook trapped/passed above the weir were adjusted to account for the estimated numbers of returning unclipped hatchery salmon without a coded wire tag. Note: because of errors identifying sex at time of capture, the numbers of male and female salmon kept for broodstock in the weir data may not match the number reported here. We use spawning records from Lookingglass Fish Hatchery to adjust age and sex of salmon kept for broodstock.

Stock, Disposition	Hatchery							Natural							Grand total
	Age 3		Age 4		Age 5		Total	Age 3		Age 4		Age 5		Total	
	M	F	M	F	M	F		M	F	M	F	M	F		
<u>Innaha River</u>															
Trapped ^a	220	3	399	459	42	68	1,191	33	0	224	162	43	63	525	1,716
Passed above the weir	5	1	184	154	26	46	416	33	0	186	130	39	53	441	857
Released below the weir ^b	18	0	46	102	0	0	166	0	0	0	0	0	0	0	166
Outplanted	11	1	84	100	8	11	215	0	0	0	0	0	0	0	215
Foodbank/tribal distribution	10	0	0	0	0	0	10	0	0	0	0	0	0	0	10
Stream Enrichment	171	0	6	0	0	0	177	0	0	0	0	0	0	0	177
Trap Morts	1	0	0	5	0	0	6	0	0	2	0	0	0	2	8
Kept for broodstock ^c	4	1	79	98	8	11	201	0	0	36	32	4	10	82	283
Weir age & sex composition (%)	18.5	0.3	33.5	38.5	3.5	5.7	100	6.3	0	42.6	30.9	8.2	12.0	100	
<u>Catherine Creek^d</u>															
Trapped ^a	42	1	92	119	8	9	271	9	1	87	135	21	7	260	531
Passed above the weir	16	0	71	96	7	6	196	9	0	71	112	18	3	213	384
Outplanted: Indian Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outplanted: Lookingglass Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Foodbank/tribal distribution	23	1	0	0	0	0	24	0	0	0	0	0	0	0	24
Trap Morts	0	0	1	0	0	0	1	0	0	0	1	0	0	1	2
Kept for broodstock ^c	3	0	20	23	1	3	50	0	1	16	22	3	4	46	96
Weir age & sex composition (%)	15.5	0.3	34.0	43.9	3.0	3.3	100	3.4	0.4	33.4	52.0	8.1	2.7	100	
<u>Upper Grande Ronde River^d</u>															
Trapped ^a	4	0	68	130	11	10	223	1	0	27	40	3	2	73	296
Passed above the weir	1	0	12	81	2	5	101	1	0	8	31	2	1	43	144
Trap Morts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kept for broodstock ^c	3	0	56	49	9	5	122	0	0	19	9	1	1	30	152
Weir age & sex composition (%)	1.8	0	30.5	58.3	4.9	4.5	100	1.4	0.0	37.0	54.8	4.1	2.7	100	

Table 5 continued.

Stock, Disposition	Hatchery							Natural							Grand total
	Age 3		Age 4		Age 5		Total	Age 3		Age 4		Age 5		Total	
	M	F	M	F	M	F		M	F	M	F	M	F		
Lookingglass Creek															
Trapped ^a	109	1	264	224	19	10	627	5	0	173	156	9	6	349	976
Passed above the weir	0	0	189	144	8	1	342	5	0	150	134	6	2	297	639
Trap Morts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Killed & Buried	11	0	4	0	0	1	16	0	0	0	0	0	0	0	16
Foodbank: Lookingglass Cr	80 ^f	0	10	0	0	0	90	0	0	0	0	0	0	0	90
Lookingglass broodstock ^c	13	1	45	60	11	7	135	0	0	23	22	3	4	52	187
Stray: UGR Broodstock	5	0	16	20	0	1	44	0	0	0	0	0	0	0	44
Weir age & sex composition (%)	17.4	0.2	42.1	35.7	3.0	1.6	100	1.4	0	49.6	44.7	2.6	1.7	100	
Lostine River^e															
Trapped ^a	151	0	191	262	54	30	688	17	1	211	217	49	46	541	1,229
<i>First time captures</i>															
Passed above the weir	15	0	125	202	39	21	402	12	1	170	181	38	32	434	836
Moved upstream in a truck	0	0	25	5	1	0	31	5	0	23	21	4	4	57	88
Trap Morts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribal distribution from weir	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
Kept for broodstock ^c	6	0	47	52	4	14	123	0	0	15	22	6	6	49	172
Recycle to Fishery ^g	92	0	2	0	0	0	94	0	0	0	0	0	0	0	94
Wallowa R: Wade Gulch ^h	26	0	0	0	0	0	26	0	0	0	0	0	0	0	26
Wallowa R: School Flat Rd ⁱ	12	0	0	0	0	0	12	0	0	0	0	0	0	0	12
Weir age & sex composition (%)	21.9	0.0	28.9	37.7	6.4	5.1	100	3.1	0.2	38.5	41.5	8.9	7.8	100	
<i>Recaptures^j</i>															
Passed above the weir	1	0	1	0	0	0	2	0	0	2	0	0	0	2	4
Recycle to Fishery ^g	25	0	0	0	0	0	25	0	0	0	0	0	0	0	25
Wallowa R: Wade Gulch ^h	55	0	0	0	0	0	55	0	0	0	0	0	0	0	55
Wallowa R: School Flat Rd ⁱ	12	0	0	0	0	0	12	0	0	0	0	0	0	0	12

^a The number trapped was adjusted to account for final origin, age, and sex structure of Chinook Salmon retained for broodstock

^b Recaptured individuals that were subsequently removed from the weir (e.g., broodstock, killed, outplanted) or were passed above the weir were excluded from the number of Chinook Salmon placed below the weir.

^c Numbers kept for broodstock were adjusted for origin, age, and sex structure using spawning records from Lookingglass Fish Hatchery

^d Operated by Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Data provided by Mike McLean (CTUIR).

^e Operated by Nez Perce Tribe (NPT). Data provided by Shane Vatland (NPT).

^f Two jacks visually identified as strays from the Upper Grande Ronde CHP program were foodbanked.

^g Released in the Wallowa River at the confluence of the Wallowa and Minam Rivers (N45.62174 E-117.72166; WGS84, decimal degrees) for the purpose of being recycled through the fishery. Chinook Salmon recaptured at the weir that were identified as being recycled to the fishery, and were subsequently removed from the weir (e.g. broodstock) or passed above the weir, were subtracted from the total number recycled to the fishery.

^h Released in the Wallowa River at Wade Gulch (N45.475166 E-117.387606; WGS84, decimal degrees) for the purpose of natural spawning.

ⁱ Released in the Wallowa River at School Flat Road Bridge (N45.501760 E-117.415034; WGS84, decimal degrees) for the purpose of natural spawning.

^j Recaptures were identified by the OP mark.

Table 6. Spawning summaries of spring Chinook Salmon from the Conventional Hatchery Programs at Lookingglass Fish Hatchery for the Imnaha and Grande Ronde basins, 2016.

Stock	Number of parents						Number of green eggs collected	Mean fecundity	Number of eyed eggs	Percent mortality to shocking
	Hatchery			Natural						
	F	Males ^a		F	Males ^a					
	Unique	Multiple ^b		Unique	Multiple ^b					
Imnaha River	96	73 ^c	74	39	40 ^c	60	578,733	4,287	558,531	3.5
Catherine Creek	16	21	21	22	15	17	153,333	4,035	132,411	13.6
Upper Grande Ronde River	60	56	64	9	15	17	256,237	3,714	235,878	7.9
Lookingglass Creek	56	41 ^d	47	21	23	35	272,810	3,543	250,865	8.0
Lostine River	54	44 ^e	49	20	19 ^e	26	319,692	4,320	277,197	13.3

^a Male counts include jacks.

^b The numbers of male parents is greater than the number of males that were spawned and the number of males kept because some males were spawned more than once. Two males were generally spawned with two females in a 2x2 matrix; other matrices were occasionally used at the end of a spawn day, according to the number of ripe females available that day. The most common other matrix used was 1 female x 2 males.

^c Eight natural origin males and 10 hatchery origin males were live spawned at Lookingglass Fish Hatchery and returned to the Imnaha River on 9 September 2016.

^d Two hatchery origin males were live spawned at Lookingglass Fish Hatchery and returned to Lookingglass Creek on 13 September 2016.

^e Five natural origin males and seven hatchery origin males were live spawned at Lookingglass Fish Hatchery and returned to the Lostine River on 9 September 2016.

Table 7. Numbers of female Chinook Salmon used in BY 2016 production and their mean egg weight (g) by stock, origin (hatchery or natural), and age. P-value for t-test comparing hatchery vs. natural salmon mean egg weights for each stock.

Stock		Hatchery				Natural				P-value
		Age 3	Age 4	Age 5	Total/ mean	Age 3	Age 4	Age 5	Total/ mean	
Imnaha River*	Females	NA	84	11	95	NA	29	10	39	0.027
	Mean egg wt.	NA	0.253	0.286	0.257	NA	0.264	0.293	0.271	
Catherine Creek	Females	NA	13	3	16	NA	18	4	22	0.513
	Mean egg wt.	NA	0.225	0.246	0.229	NA	0.218	0.248	0.223	
Upper Grande Ronde River*	Females	NA	54	4	58	NA	8	1	9	0.609
	Mean egg wt.	NA	0.222	0.232	0.222	NA	0.224	0.253	0.227	
Lookingglass Creek*	Females	1	48	6	55	NA	16	4	20	0.001
	Mean egg wt.	0.174	0.217	0.235	0.218	NA	0.249	0.284	0.256	
Lostine River*	Females	NA	40	11	51	NA	14	5	19	0.034
	Mean egg wt.	NA	0.242	0.262	0.246	NA	0.253	0.296	0.265	

* The asterisk indicates stocks where the number of females with mean egg weights is less than the number of females spawned.

Table 8. Catch and escapement summary of BY 2011–2013 smolts that were released into the Imnaha River and returned in 2016. Estimated coded-wire tag (CWT) recoveries were summarized through 28 February 2018 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2013)			Age 4 (BY 2012)			Age 5 (BY 2011)			Total
	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	
Total Smolts Released	331,702			346,702			390,703			
% Ad + CWT	75.6%			63.8%			55.6%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	1	2	2	0	0	0	2
Columbia River										
Tribal	1	5	7	17	103	162	4	34	60	229
Non-tribal net	1	1	1	15	36	57	4	9	16	75
Sport	7	32	43	16	77	120	1	5	8	171
Snake River										
Sport ^a	0	0	0	2	4	7	0	0	0	7
Tribal ^a	0	0	0	0	0	0	0	0	0	0
Stray below LGD ^b	0	0	0	1	1	2	0	0	0	2
Stray above LGD ^{a,b}	0	0	0	0	0	0	0	0	0	0
Recruitment to river ^a										
Sport Fisheries ^c	1	--	11	10	--	100	0	--	13	124
Tribal Fisheries ^c	0	--	2	0	--	144	0	--	16	162
Above weir estimate ^d	1	--	6	35	--	342	5	--	73	421
Below weir estimate ^d	0	--	79	8	--	282	6	--	48	409
Removed at weir ^d	135	--	199	85	--	372	10	--	38	609
Compensation area return	137	--	297	140	--	1,247	21	--	188	1,732
Total/Total estimated return	146	--	349	190	--	1,590	30	--	272	2,211

^a Indicates areas within LSRCPC compensation area.

^b Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.

^c CWT samples were not collected from the fishery.

^d Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Imnaha River hatchery salmon.

Table 9. Total smolts released, and total returns (age 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Imnaha River for hatchery-reared spring Chinook Salmon released into the Imnaha River, complete brood years 1982-2011. SAR data were updated on 17 May 2018.

Brood Year	Total smolts released	Total returns to Lower Granite Dam		Total returns to river mouth	
		Total	SAR	Total	SAR
1982	29,184 ^a	208	0.713	208	0.713
1983	59,595	80	0.134	80	0.134
1984	35,782	112	0.313	111	0.310
1985	123,533 ^b	207	0.168	206	0.167
1986	199,506	502	0.252	502	0.252
1987	142,320	389	0.274	389	0.274
1988	253,869	2,025	0.798	2,025	0.798
1989	267,670	672	0.251	672	0.251
1990	262,500	98	0.037	98	0.037
1991	157,659	103	0.065	103	0.065
1992	438,617	206	0.047	206	0.047
1993	590,118	1,062	0.180	1,062	0.180
1994	91,240	102	0.111	102	0.111
1995	50,903	536	1.053	536	1.053
1996	93,112	916	0.984	916	0.984
1997	194,958	3,381	1.734	3,379	1.733
1998	179,972	4,697	2.610	4,689	2.605
1999	123,009	1,248	1.015	1,242	1.010
2000	303,717	2,341	0.771	2,312	0.761
2001	268,420	1,816	0.677	1,811	0.675
2002	398,178	1,496	0.376	1,388	0.349
2003	435,187	1,358	0.312	1,358	0.312
2004	441,680	3,673	0.832	3,672	0.831
2005	432,530	3,488	0.806	3,488	0.806
2006	348,909	8,932	2.560	8,884	2.546
2007	293,801	3,696	1.258	3,696	1.258
2008	390,062	4,639	1.189	4,616	1.183
2009	252,588	1,257	0.498	1,256	0.497
2010	469,807	2,348	0.500	2,333	0.497
<u>2011</u>	<u>390,703</u>	<u>4,731</u>	<u>1.211</u>	<u>4,713</u>	<u>1.206</u>
Mean	287,348	1,877	0.724	1,868	0.722

^a Includes 4,264 Lookingglass creek smolts that were accidentally mixed into the Imnaha ponds during an ice-up event.

^b Smolts were scheduled for release into the Imnaha River, but were released into Lookingglass Creek on 20 April 20 because they were infected with Viral Erythrocytic Necrosis.

Table 10. Catch and escapement summary of BY 2011–2013 Conventional Hatchery program smolts that were released into Catherine Creek and returned in 2016. Estimated coded-wire tag (CWT) recoveries were summarized through 28 February 2018 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2013)			Age 4 (BY 2012)			Age 5 (BY 2011)			Total
	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	
Total Smolts Released	146,310			138,370			134,520			
% Ad + CWT	71.9%			65.6%			63.3%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	1	18	28	0	0	0	28
Non-tribal net	1	2	2	3	6	8	0	0	0	10
Sport	0	0	0	4	16	24	0	0	0	24
Snake River										
Sport ^a	0	0	0	1	2	3	0	0	0	3
Tribal ^a	0	0	0	0	0	0	0	0	0	0
Stray below LGD ^b	0	0	0	0	0	0	0	0	0	0
Stray above LGD ^{a,b}										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin ^c	3	--	3	12	--	42	0	--	0	45
Grande Ronde Pilot Fishery ^a	0	0	0	0	0	0	0	0	0	0
Recruitment to river ^a										
Sport Fisheries	0	--	0	0	--	0	0	--	0	0
Tribal Fisheries	0	--	0	0	--	0	0	--	0	0
Above weir estimate ^c	0	--	16	10	--	167	0	--	13	196
Below weir estimate ^c	0	--	1	0	--	4	0	--	0	5
Removed at weir ^c	18	--	27	30	--	44	2	--	4	75
Compensation area return	21	--	47	53	--	260	2	--	17	324
Total/Total estimated return	22	--	49	61	--	320	2	--	17	386

^a Indicates areas within LSRCF compensation area.

^b Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.

^c Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Catherine Creek hatchery salmon.

Table 11. Catch and escapement summary of BY 2011–2013 Conventional Hatchery program smolts that were released into the Upper Grande Ronde River and returned in 2016. Estimated coded-wire tag (CWT) recoveries were summarized through 28 February 2018 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2013)			Age 4 (BY 2012)			Age 4 (BY 2011)			Total
	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	
Total Smolts Released	224,443			241,169			290,821			
% Ad + CWT	47.5%			48.6%			49.4%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	1	18	39	3	3	6	1	1	1	46
Non-tribal net	0	0	0	5	9	19	0	0	0	19
Sport	1	5	10	9	34	72	0	0	0	82
Snake River										
Sport ^a	0	0	0	1	2	4	0	0	0	4
Tribal ^a	0	0	0	0	0	0	0	0	0	0
Stray below LGD ^b	0	0	0	0	0	0	0	0	0	0
Stray above LGD ^{a,b}										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin ^c	18	--	25	63	--	124	5	--	6	155
Grande Ronde Pilot Fishery ^a	0	0	0	0	0	0	0	0	0	0
Recruitment to river ^a										
Sport Fisheries	0	--	0	0	--	0	0	--	0	0
Tribal Fisheries	0	--	0	0	--	2	0	--	0	2
Above weir estimate ^c	2	--	21	9	--	139	2	--	11	171
Below weir estimate ^c	0	--	0	0	--	0	0	--	0	0
Removed at weir ^c	3	--	3	103	--	106	12	--	14	123
Compensation area return	23	--	49	176	--	375	19	--	31	455
Total/Total estimated return	25	--	98	193	--	472	20	--	32	602

^a Indicates areas within LSRCF compensation area.

^b Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.

^c Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Upper Grande Ronde River hatchery salmon.

Table 12. Catch and escapement summary for BY 2011–2013 Conventional Hatchery Program smolts that were released into Lookingglass Creek and returned in 2016. Estimated coded-wire tag (CWT) recoveries were summarized through 28 February 2018 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

Total Smolts Released % Ad + CWT	Age 3 (BY 2013)			Age 3 (BY 2012)			Age 4 (BY 2011)			Total
	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	
	0	0	0	0	0	0	0	0	0	0
Ocean catch	0	0	0	0	0	0	0	0	0	0
Columbia River										
Tribal	0	0	0	4	29	51	0	0	0	51
Non-tribal net	1	2	3	7	12	20	0	0	0	23
Sport	0	0	0	14	55	96	3	12	25	121
Snake River										
Sport ^a	0	0	0	4	9	15	0	0	0	15
Tribal ^a	0	0	0	0	0	0	0	0	0	0
Stray below LGD ^b	0	0	0	0	0	0	0	0	0	0
Stray above LGD ^{a,b}										
Outside GR Basin	0	0	0	1	1	1	0	0	0	1
GR Basin ^c	0	--	0	3	--	15	0	--	0	15
Grande Ronde Pilot Fishery ^a	0	0	0	0	0	0	0	0	0	0
Recruitment to river ^a										
Sport Fisheries	0	--	47	0	--	42	0	--	2	91
Tribal Fisheries	0	--	0	0	--	56	0	--	3	59
Above weir estimate ^c	0	--	6	40	--	322	0	--	19	347
Below weir estimate ^c	5	--	41	59	--	181	3	--	10	232
Removed at weir ^c	49	--	103	64	--	119	8	--	19	241
Compensation area return	54	--	197	171	--	751	11	--	53	1,001
Total/Total estimated return	55	--	200	196	--	918	14	--	78	1,196

^a Indicates areas within LSRCPC compensation area.

^b Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.

^c Expanded based on the estimated total return to the natal stream of mature (ages 3-5) Lookingglass Creek basin hatchery salmon.

Table 13. Catch and escapement summary for BY 2011–2013 Conventional Hatchery program smolts that were released into the Lostine River and returned in 2016. Estimated coded-wire tag (CWT) recoveries were summarized through 28 February 2018 from the PSMFC database and expanded to account for recoveries of adipose-clipped Chinook Salmon without a CWT. Recruitment to the river incorporates weir records in addition to CWT data.

	Age 3 (BY 2013)			Age 4 (BY 2012)			Age 5 (BY 2011)			Total
	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	
Total Smolts Released	249,369			232,924			265,039			
% Ad + CWT	57.6%			53.8%			49.5%			
Location, recovery type	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	CWT recoveries	Est. CWT	Expanded Return	Total
Ocean catch	0	0	0	1	3	5	0	0	0	5
Columbia River										
Tribal	0	0	0	9	47	88	4	25	49	137
Non-tribal net	0	0	0	9	17	31	1	2	3	34
Sport	3	14	24	6	28	52	3	13	27	103
Snake River										
Sport ^a	0	0	0	0	0	0	0	0	0	0
Tribal ^a	0	0	0	0	0	0	0	0	0	0
Stray below LGD ^b	0	0	0	2	2	4	1	1	2	6
Stray above LGD ^{a,b}										
Outside GR Basin	0	0	0	0	0	0	0	0	0	0
GR Basin ^c	3	--	9	2	--	18	0	--	0	27
Grande Ronde Pilot Fishery ^a	0	0	0	0	0	0	0	0	0	0
Recruitment to river ^a										
Sport Fisheries	0	--	0	0	--	0	0	--	0	0
Tribal Fisheries	0	--	4	0	--	109	0	--	19	132
Above weir estimate ^c	1	--	15	39	--	474	5	--	82	571
Below weir estimate ^c	0	--	19	1	--	101	2	--	18	138
Removed at weir ^c	7	--	136	46	--	102	7	--	18	256
Compensation area return	11	--	183	88	--	804	14	--	137	1,124
Total/Total estimated return	14	--	207	115	--	984	23	--	218	1,409

^a Indicates areas within LSRCP compensation area.

^b Estimated total number of CWT salmon recovered from PSMFC and ODFW databases.

^c Expanded based on estimated total return to natal stream of mature (ages 3-5) of Lostine River hatchery salmon.

Table 14. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and Catherine Creek for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into Catherine Creek, complete brood years 1998-2011. SAR data were updated on 17 May 2018.

Brood Year	Program	Total smolts released	Total returns to Lower Granite Dam		Total returns to river mouth	
			Total	SAR	Total	SAR
1998	CBS	37,982	425	1.119	419	1.103
1999	CBS	136,820	270	0.197	245	0.179
2000	CBS	180,340	693	0.384	673	0.373
2001	CBS	105,292	132	0.125	112	0.106
2001	CHP	24,392	80	0.328	78	0.320
2002	CBS	91,796	74	0.081	69	0.075
2002	CHP	70,072	210	0.300	200	0.285
2003	CBS	68,827	47	0.068	41	0.060
2003	CHP	120,754	132	0.109	121	0.100
2004	CBS	45,604	113	0.248	109	0.239
2004	CHP	23,216	88	0.379	84	0.362
2005	CBS	21,574	41	0.190	36	0.167
2005	CHP	49,696	246	0.495	227	0.457
2006	CHP	116,882	1,488	1.273	1,417	1.212
2007	CHP	138,842	855	0.616	763	0.550
2008	CBS	34,111	275	0.806	245	0.718
2008	CHP	110,242	1,073	0.973	992	0.900
2009	CBS	96,738	169	0.175	156	0.161
2009	CHP	58,737	171	0.291	162	0.276
2010	CHP	161,373	791	0.490	705	0.437
<u>2011</u>	<u>CHP</u>	<u>134,520</u>	<u>529</u>	<u>0.393</u>	<u>514</u>	<u>0.382</u>
Mean	CBS/CHP	83,082	376	0.430	351	0.403

Table 15. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Upper Grande Ronde River for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into the Upper Grande Ronde River, complete brood years 1998–2011. SAR data were updated on 17 May 2018.

Brood Year	Program	Total smolts released	Total returns to Lower Granite Dam		Total returns to river mouth	
			Total	SAR	Total	SAR
1998	CBS	1,508	5	0.332	5	0.332
1999	CBS	2,559	11	0.430	11	0.430
2000	CBS	151,443	655	0.433	626	0.413
2001	CBS	210,113	326	0.155	311	0.148
2001	CHP	26,923	164	0.609	151	0.561
2002	CBS	75,063	3	0.004	3	0.004
2002	CHP	69,856	178	0.255	166	0.238
2003	CBS	1,019	0	0.000	0	0.000
2003	CHP	104,350	41	0.039	41	0.039
2004	CBS	76	0	0.000	0	0.000
2004	CHP	18,901	82	0.434	82	0.434
2005	CBS	20,620	121	0.587	115	0.558
2005	CHP	118,803	766	0.645	762	0.641
2006	CHP	259,932	3,017	1.161	2,856	1.099
2007	CBS	52,404	422	0.805	397	0.758
2007	CHP	94,148	602	0.639	579	0.615
2008	CBS	190,530	840	0.441	771	0.405
2008	CHP	41,819	539	1.288	508	1.215
2009	CBS	53,114	100	0.188	75	0.141
2009	CHP	189,271	573	0.303	502	0.265
2010	CHP	285,738	1,467	0.513	1,346	0.471
2011	CBS	155,264	540	0.348	486	0.313
<u>2011</u>	<u>CHP</u>	<u>135,557</u>	<u>1,256</u>	<u>0.926</u>	<u>1,193</u>	<u>0.880</u>
Mean	CBS/CHP	94,125	509	0.458	478	0.433

Table 16. Total smolts released, and total returns (ages 3-5) and smolt-to-adult return rates (SAR) to Lower Granite Dam and Lookingglass Creek for hatchery-reared smolts released into Lookingglass Creek from either the Catherine Creek Captive Broodstock (CBS) or Lookingglass Creek Conventional Hatchery (CHP) programs, complete brood years 2000–2011. SAR data were updated on 17 May 2018.

Brood Year	Program	Total smolts released	Total returns to Lower Granite Dam		Total returns to river mouth	
			Total	SAR	Total	SAR
2000	CBS	51,864 ^a	78	0.150	65	0.125
2001	CBS	17,880 ^a	65	0.364	65	0.366
2002	CBS	53,333	111	0.208	110	0.207
2003	CBS	98,023	167	0.170	164	0.167
2004	CHP	126,197	506	0.401	446	0.353
2005	CHP	0	NA	NA	NA	NA
2006	CBS	43,219	776	1.796	717	1.660
2007	CBS/CHP ^b	150,478	1,764	1.172	1,439	0.956
2008	CHP	262,910	2,955	1.124	2,937	1.117
2009	CHP	101,759	495	0.491	442	0.439
2010	CHP	228,565	2,431	1.064	2,220	0.971
<u>2011</u>	<u>CHP</u>	<u>273,097</u>	<u>1,626</u>	<u>0.595</u>	<u>1,595</u>	<u>0.584</u>
Mean	CBS/CHP	133,758	1,675	1.040	1,558	0.955

^a Parr releases, not smolts.

^b Released 100,450 Catherine Creek CBS smolts and 50,028 Lookingglass Creek CHP smolts. All smolts were marked with an adipose fin clip and a CWT.

Table 17. Total smolts released, and total returns (ages 3-5), and smolt-to-adult return rates (SAR) to Lower Granite Dam and the Lostine River for hatchery-reared smolts produced from the Captive Broodstock (CBS) and Conventional Hatchery (CHP) programs and released into the Lostine River, complete brood years 1998–2011. SAR data were updated on 17 May 2018.

Brood Year	Program	Total smolts released	Total returns to Lower Granite Dam		Total returns to river mouth	
			Total	SAR	Total	SAR
1997	CHP	11,870	237	1.997	233	1.966
1998	CBS	34,985	590	1.686	576	1.646
1999	CBS	133,880	312	0.233	291	0.217
2000	CBS	77,312	673	0.870	642	0.830
2000	CHP	31,464	429	1.363	413	1.312
2001	CBS	141,867	440	0.310	434	0.306
2001	CHP	100,882	661	0.655	646	0.640
2002	CBS	133,729	191	0.143	183	0.137
2002	CHP	116,370	327	0.281	313	0.269
2003	CBS	62,149	113	0.182	112	0.180
2003	CHP	102,556	266	0.259	250	0.244
2004	CBS	40,982	120	0.293	111	0.271
2004	CHP	197,950	1,305	0.659	1,192	0.602
2005	CBS	24,604	219	0.890	207	0.840
2005	CHP	205,407	1,900	0.925	1,881	0.916
2006	CBS	10,470	201	1.920	201	1.919
2006	CHP	194,594	5,360	2.754	5,110	2.626
2007	CBS	61,927	1,322	2.135	1,316	2.125
2007	CHP	185,765	2,783	1.498	2,718	1.463
2008	CBS	60,997	893	1.464	872	1.429
2008	CHP	182,666	1,925	1.054	1,827	1.000
2009	CBS	1,905	22	1.155	11	0.577
2009	CHP	60,931	228	0.374	213	0.350
2010	CHP	267,352	2,306	0.863	2,281	0.853
<u>2011</u>	<u>CHP</u>	<u>265,039</u>	<u>2,682</u>	<u>1.012</u>	<u>2,504</u>	<u>0.945</u>
Mean	CBS/CHP	104,141	1,020	0.999	981	0.947

Table 18. Summary of hatchery and natural origin Chinook Salmon carcasses recovered and number of redds observed by stream during spawning ground surveys in the Imnaha River and Grande Ronde River basins, 2016. NS = Not Surveyed.

Basin, stream	Carcasses			Percent hatchery ^a	Number of redds
	Hatchery	Natural	Unknown origin		
<u>Imnaha River Basin</u>					
Big Sheep Creek	3	5	0	0.0	22
Imnaha River	145	155	5	48.3	425
Lick Creek	<u>6</u>	<u>0</u>	<u>0</u>	<u>0.0</u>	<u>34</u>
Total	154	160	5	49.0	481
<u>Grande Ronde River Basin</u>					
Bear Creek	0	6	0	0.0	35
Catherine Creek	15	27	1	35.7	146
Hurricane Creek	10	46	0	17.9	55
Limber Jim Creek	0	0	0	0.0	0
Lookingglass Creek ^{b,c}	266	136	4	66.2	351
Lostine River	160	142	3	53.0	225
McCoy Creek	NS	NS	NS	NS	NS
Meadow Creek	NS	NS	NS	NS	NS
Minam River ^d	0	23	2	0.0	186
Sheep Creek	0	0	0	0.0	0
Upper Grande Ronde River	10	2	7	83.3	73
Wallowa River	8	17	1	32.0	48
Wenaha River	<u>9</u>	<u>45</u>	<u>2</u>	<u>16.7</u>	<u>298</u>
Total	478	444	20	51.8	1,417

^a Percent of carcasses of known origin.

^b Data provided by CTUIR.

^c Includes Little Lookingglass Creek.

^d Includes Little Minam River.

Table 19. Summary of coded-wire tags (CWT) recovered from hatchery Chinook Salmon carcasses during spawning ground surveys in the Imnaha River and Grande Ronde River basins, 2016.

Recovery location	Brood year	CWT code	Number recovered	Release site	
<u>Imnaha River Basin</u>					
Big Sheep Creek	2012	090766	1	Imnaha River	
Imnaha River	2011	090549	2	Imnaha River	
		090550	5	Imnaha River	
		090551	2	Imnaha River	
		090552	2	Imnaha River	
	2012	090764	7	Imnaha River	
		090765	12	Imnaha River	
		090766	13	Imnaha River	
	2013	090767	1	Imnaha River	
		090802	1	Imnaha River	
	Lick Creek	2012	090766	1	Imnaha River
090767			1	Imnaha River	
<u>Grande Ronde River Basin</u>					
Catherine Creek	2012	090754	5	Catherine Creek	
		090755	5	Catherine Creek	
Hurricane Cr	2012	090754	1	Catherine Creek	
		090763	2 ^a	Lostine River	
Lookingglass Creek ^c	2013	090790	3 ^b	Lostine River	
	2011	090541	2	Lookingglass Creek	
		090542	1	Lookingglass Creek	
		090545	1	Upper Grande Ronde River	
	2012	090754	2	Catherine Creek	
		090756	44	Lookingglass Creek	
		090757	54	Lookingglass Creek	
		090758	3	Upper Grande Ronde River	
		090759	12	Upper Grande Ronde River	
		090760	3	Upper Grande Ronde River	
		090761	6	Upper Grande Ronde River	
		636507	1	Columbia River, Priest Rapids	
		2013	090784	2	Lookingglass Creek
			090785	1	Lookingglass Creek
	090786		1	Lookingglass Creek	
090787	1		Lookingglass Creek		
Lostine River	2011	090798	1	Upper Grande Ronde River	
		090547	2	Lostine River	
		090548	5	Lostine River	

Table 19 continued.

Recovery location	Brood year	CWT code	Number recovered	Release site
Lostine River	2012	090754	1	Catherine Creek
		090756	1	Lookingglass Creek
		090762	9	Lostine River
		090763	31	Lostine River
Minam River ^d	2013	090790	1	Lostine River
	NA	NA	0	No CWT's
Upper Grande Ronde River	2011	090544	1	Upper Grande Ronde River
		090546	1	Upper Grande Ronde River
	2012	090758	1	Upper Grande Ronde River
		090759	1	Upper Grande Ronde River
		090760	5	Upper Grande Ronde River
		090761	2	Upper Grande Ronde River
	2013	090796	1	Upper Grande Ronde River
		090799	1	Upper Grande Ronde River
Wallowa River	2012	090759	1	Upper Grande Ronde River
		090762	1	Lostine River
	2013	090789	1	Lostine River
		090791	1	Lostine River
Wenaha River	2012	090792	1 ^e	Lostine River
		090719	1	Umatilla River
		090756	1	Lookingglass Creek

^a One of the CWT recoveries was from a hatchery salmon outplanted into the Wallowa River from the Lostine River weir.

^b Two of the CWT recoveries were from hatchery salmon outplanted into the Wallowa River from the Lostine River weir.

^c Data provided by CTUIR. Includes Little Lookingglass Creek.

^d Includes the Little Minam River.

^e Identified as an outplant from the Lostine River by the 2ROP punch on the opercle plate.

Table 20. Numbers of female Chinook Salmon carcasses recovered on the spawning grounds that were classified as either a pre-spawn mortality ($\geq 50\%$ of eggs remained in carcass), spawned ($< 50\%$ of eggs remained in carcass), or unknown, and the pre-spawn mortality rates, 2016.

Recovery location	Pre-spawn mortality	Spawned	Unknown	% Pre-spawn mortality
<u>Innaha River Basin</u>				
Big Sheep Creek	0	1	0	0.0
Innaha River	3	16	5	15.8
Lick Creek	0	0	0	0.0
<u>Grande Ronde River Basin</u>				
Bear Creek	0	5	0	0.0
Catherine Creek	0	12	0	0.0
Hurricane Creek	0	5	0	0.0
Lookingglass Creek ^a	2	39	2	4.9
Lostine River	9	32	2	21.9
Minam River	0	0	0	0.0
Sheep Creek	0	0	0	0.0
Upper Grande Ronde River	0	1	1	0.0
Wallowa River	0	5	2	0.0
Wenaha River	0	6	0	0.0

^a Data provided by CTUIR. Includes Little Lookingglass Creek.

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